Chemical & Process Engineering

Vol. 34, No. 3 **CONTENTS** MARCH 1953

TOPICS OF THE MONTH 63

Chemical Engineering Review: MIXING *by D. F. Riley, B.Sc., A.C.G.I.* 67

NICKEL CRACKING CATALYSTS 72

LAYOUT, CONSTRUCTION AND EQUIPMENT OF CHEMICAL FACTORIES 73

GLUE AND GELATIN MANUFACTURE 77

Chemical Engineering Review: CENTRIFUGING *by E. Broadwell* 78

RECENT PUBLICATIONS 82

CARBON DIOXIDE FROM FUEL OIL 83

WASTE HEAT FROM BRICK KILNS HELPS FUEL ECONOMY SCHEME 84

ION EXCHANGE AND FINE CHEMICALS 85

CHEMICAL ENGINEERING INVENTION 86

WHITE BREAD WITHOUT AGENE 86

PLANT AND EQUIPMENT:
Heavy-duty relay; Improved pH meter; Portable liquid transfer unit; Welding accessory; Flexible metal tubing 87

WORLD NEWS:
From Great Britain, Norway, Finland, Sweden, Holland, Turkey, Yugoslavia, Japan, Indonesia, Brazil, Mexico, Venezuela, Pakistan, India, South Africa, Australia, Canada, United States 88

ABSORPTION AND EXTRACTION (Book Review) 91

MODERN CHEMICAL PLANTS (Book Review) 91

MEETINGS 92

Subscription rates: *1 year 6 dollars, 3 years 15 dollars, paid in advance*

England: Leonard Hill Limited, Stratford House, 9 Eden Street, London, N.W.1 *U.S.A.: British Publications Inc., 150, East 35th St., New York, 16*

Topics of the Month

Pipelines for coal

THE pumping of solids through pipelines is an attractive and established means of transporting such materials as coal slack, gravel, ores, etc. Now comes news of a scheme sponsored by the Ministry of Fuel for pumping coal through a pipeline. The idea is not new. Some 40 years ago the borough electrical engineer of Hammersmith, London, a Mr. Bell, devised and operated a system for pumping coal from a Thames-side wharf to the electricity works. More recently (April 1951) we commented on the plans of an American company to build a 17,000-ft. demonstration pipeline for pumping coal as a slurry and in this issue (p. 73) there is mention of a projected $6 million pipeline, 100 miles long, for transporting 7,000 tons/day of coal as a slurry. The new British scheme also involves the construction of a 100-miles-long pipeline to transport perhaps a million tons of coal p.a. from the Midlands to London.

The 100-mile pipeline is necessarily a long-term objective. For the present, according to a report in the *Times*, development work has started on a scheme for the transport of 100 tons/hr. of 3-in. coal over a sufficiently long distance to make intermediate pumping stages necessary. The unit could take several forms. Some or all of the coal might be passed through the pump, or it might be fed into the pipe on the pressure side of the pump, which might be of the reciprocating or centrifugal type. For the first experimental unit, a centrifugal pump passing water only and a hopper device for feeding the coal into the pipeline have been chosen. This unit will be tried first at Markham Colliery in the East Midlands Division of the National Coal Board, where a pilot coal-pumping unit is already working. The final plant will be designed to convey 100 tons/hr. of coal, up to 2 in. in size, from the top of the shaft to the central washery about 1,000 ft. away.

These schemes differ in technique from the American installations mentioned. The latter call for the crushing of the coal to a fine size and its mixing with water to form a slurry. The British systems are being designed for coal of up to 5 in. in size. If hydraulic transport can be made to work it could revolutionise the mining of coal, for the output of many pits is limited by the winding capacity of their shafts.

Fundamental work on hydraulic transport is the province of the chemical engineer and, at Imperial College, Prof. D. M. Newitt, F.R.S., is working on the problem. The main work, however, is being done by the specialists in hydraulics, the new British Hydromechanics Research Association in their laboratories at Harlow, Essex, with the sponsorship of the National Coal Board. In their recently issued annual report for 1951-52 the Association briefly discuss the problem. They state that the factors involved in predicting the head loss and water velocity include the size distribution, shape, density and concentration of the material being pumped, and the diameter and slope of the pipe. Some success has been scored by theoretical analysis of published data, but there are big gaps in available knowledge. To supply this missing information, an experimental rig in which varying concentrations can be circulated through a 3-in. experimental pipeline has been constructed. In addition to obtaining data of a

fundamental nature for design purposes, the Association have constructed a small-scale experimental ' coal pump ' for continually injecting coal into high-pressure water as an alternative to passing coal through the pump itself.

This experimental work and the pilot-plant experiments of the Ministry of Fuel will be eagerly followed by mining and chemical engineers who, while recognising the many difficulties in the way to success, will also perceive that the idea could make Britain's main source of energy—coal—as mobile as oil and gas.

A bigger Imperial College

ACTION has at last been taken by the Government to expand facilities for higher technological training. Having turned down the suggestion for a College of Technologists which was accepted by the Labour Government in September 1951, the Government has now set about carrying out the alternative to this scheme: the expansion of existing facilities. The institution selected for expansion is the Imperial College of Science and Technology, London University. This famous college, an amalgam of the Royal College of Science (founded as the Royal College of Chemistry in 1845), the Royal School of Mines and the City and Guilds College, is to be considerably enlarged around its present site in South Kensington. The aim is to increase the number of students to 3,000, almost double the present number, during the five years 1957-62. This development of Imperial College is in accord with the Government's policy of building up at least one institution of university rank devoted to the teaching of higher technology. Funds are also to be allocated to similar, though smaller, projects in other parts of the country.

The expansion of Imperial College is of special interest to chemical engineers because it has the largest chemical engineering department in the country. Under Profs. Sir A. C. Egerton, D. M. Newitt and G. I. Finch, FF.R.S., a wide range of research is being carried out. According to a new D.S.I.R. book, ' Scientific Research in British Universities, 1951-52,' 19 of the staff are engaged on work about which information has been published in the last four years.

The studies range over many fields including drying, condensation, evaporation, high-pressure reactions, low-temperature work and refrigeration, heat transfer, mass transfer, thermodynamics, combustion, coal chemistry, refractories, pneumatic conveying, instrumentation, blast furnaces, high-speed jets and high-speed photography. Applied chemistry research includes flame propagation, fire and explosion prevention, combustion, infra-red spectroscopy, surface chemistry, corrosion, electrodeposition, crystal growth, catalysis, plastics and mechanical wear.

Chemical engineering research in the universities

THE D.S.I.R. survey of university research in 1951-52, mentioned above, gives a comprehensive picture of the research effort on chemical engineering now being made in British universities. Such research is being done in three colleges of London University. The biggest department is at Imperial College, described in the preceding note. At University College, Prof. M. B. Donald's department has six workers doing research on which information has been published over the past four years. This, incidentally, is the criterion applied to the mention of all workers in the D.S.I.R. book. The work includes flow of powders, electrostatic separation of particles and the design of a reactor for the gaseous phase oxidation of benzene to phenol. At King's College there is a Department of Civil, Mechanical and Chemical Engineering, under Prof. S. J. Davies, and there is a staff of three working on heat pumps, heat regenerators, flow through beds of granular materials, etc.

Outside London, the biggest chemical engineering department is at Birmingham University where there is a staff of nine, under Prof. F. H. Garner, whose work falls under four main heads: distillation, combustion of hydrocarbons, fluid diffusion and mining processes, and synthesis and reaction of hydrocarbons. At Leeds University there is a department of Coal Gas and Fuel Industries with Metallurgy, under Prof. A. L. Roberts. Three workers are engaged on chemical engineering, three on fuel and gas engineering, one on process instrumentation, two on refractory materials and seven on metallurgy.

The Department of Chemical Engineering at Cambridge is under Prof. T. R. C. Fox with a staff of four working on diffusion, absorption, mixing, flame and combustion processes, distillation processes, and thermodynamics and kinetics of steady-state systems.

Manchester University has no chemical engineering research department as such, but has 28 workers in the Department of Applied Chemistry of the Faculty of Technology. Five are engaged on process investigations dealing with mass transfer, rectification, humidification, heat transfer, hydroextraction and faults in vitreous enamelling of sheet steel and cast iron. Others are working on catalytic depolymerisation of cellulose, fat formation in mould fungi, bacterial polysaccharides, etc. In addition, three are occupied in textile chemistry research, and Prof. W. E. Morton and three others on textile engineering.

Birmingham, Cambridge, Durham, Liverpool, London, Manchester, Sheffield and Wales Universities have metallurgy and mining research departments and Edinburgh, Leeds and Nottingham, mining departments.

Tool industries' troubles

MOST of the reports published by British productivity teams after their visits to the U.S. have followed a common pattern. Usually the American industry under survey has been found to have higher productivity than its British counterpart and the report has consisted largely of criticisms of British practice and recommendations for improvement. A very different report has been written by the British Productivity Team on Metal Working Machine Tools. They have found plenty to criticise, but by no means all in Britain. In their view, the machine tool industries in both countries fall very far short of the possible standard of productivity. Both British and U.S. machine tools are too dear, are not always well designed, have too much ' window-dressing ' wasted on them and are often needlessly accurate. All this adds up to low productivity and high costs with the result that, although the machine tool market is a ' must ' market, high prices greatly limit sales and accentuate the feasts and famines experienced by the machine tool industries.

The engineering industries who use machine tools will not quarrel with these strictures and will hope that the recommendations made for higher productivity will be carried out quickly. The team call for ' courageous rationalisation by energetically and ruthlessly applying the principles of simplification, standardisation and specialisation on an industry-wide basis,' concluding that ' it is vital that the industries legislate for greater volumes of fewer parts and units.'

Pressure vessel testing with radioactive sources

THE advantages of radiography with gamma-ray sources over that with *x*-ray machines was demonstrated recently in Canada when the welded joints of a 48 ft. diameter spherical pressure vessel were examined by this method. In particular, only one day had to be spent working on the tank itself, thus avoiding the lengthy delay that would have been necessary with other methods of inspection and test.

The pressure vessel that was to be examined had all joints welded, making about 2,000 ft. of welds in all : the radiographic examination was carried out by placing nearly 1,500 pieces of *x*-ray film over the seams on the outside of the tank. The isotope which was used as the gamma-ray source was lowered into the centre of the tank and left for about 16 hr., while test films were examined from time to time to ensure the right exposure. Finally, the gamma-ray source and the films were removed in about 2 hr. It is clear that very little disturbance could have been caused at the plant by the operation, while the completion of the task, which included the inspection of the radiographs, within a week of starting was, no doubt, an additional factor favouring the use of this technique for non-destructive testing.

Engineering of nitrogen separation plants

CHEMICALLY inert nitrogen is a non-combustible diluent lowering the heating value of natural gas in direct proportion to its concentration. The cost of transmission of natural gas per B.Th.U. unit is directly influenced by the concentration of nitrogen, which, as a high molecular weight constituent, increases the horsepower required for pumping.

As pointed out in these notes in our November issue, proposals have been made to remove nitrogen prior to transmission as a means of increasing pipeline effectiveness. Further, the removal of propane and ethane from high-nitrogen natural gas for petroleum chemical manufacture requires the removal of nitrogen to ensure maintenance of heating value requirements on the gas. Also, the storage of liquefied natural gas for meeting peak loads requires separation of the nitrogen to ensure uniformity of the natural gas when removed from storage.

The engineering design of plants to separate nitrogen from natural gas requires accurate data on the thermodynamic properties of nitrogen over a wide range of conditions. Previously published charts either cover an inadequate range of pressure or suffer from scale modulus limitations. To provide charts of value to the natural gas industry, researchers at the Institute of Gas Technology, affiliated with the Illinois Institute of Technology, have recalculated the usual thermodynamic properties of nitrogen on the basis of more recent fundamental data from the published literature.

'Thermodynamic Properties of Nitrogen,' by O. T. Bloomer and K. N. Rao, I.G.T. Research Bulletin No. 18, presents the properties in tabular form and as charts of enthalpy versus entropy, and of compressibility factor as a function of temperature and pressure. The range of the tables and charts is from saturated liquid at −320.4°F. to superheated vapour at 500°F., and pressures from 10 to 1,500 p.s.i.a. Properties tabulated are specific volume, enthalpy, entropy and the fugacity-to-pressure ratio. For the superheated vapour region, calculations were based on zero-pressure specific heat data and a new equation of state.

Pharmaceutical engineering science

THE development of pharmaceutical manufacture from the small-scale dispensing and compounding in the local chemist's shop of 50 years ago to the mass production of drugs in the large factories of today has brought about a change in the educational requirements of pharmacists. Factory-scale manufacture of drugs, in fact, has created the need for two different types of pharmacist—the retailer and the manufacturer. The retailer need no longer have the high technical skill demanded at the dispensing counter 50 years ago because his dispensing today is largely a matter of distributing the packed products of the manufacturing laboratories. The manufacturing pharmacist, on the other hand, requires a very different training. He must be taught to think of his work not in terms of pints and pounds but of gallons and hundredweights, perhaps tons. No longer is it possible to say, as a reference book of 1894 stated in connection with a cod liver oil preparation, 'the excellency of the emulsion is in proportion to the diligence of the operator using his mortar and pestle.' Today, pharmaceutical manufacture, like many other chemical operations, is a matter of large quantities and large plant units, the understanding of which can be accelerated by a knowledge of chemical engineering.

This need has been appreciated at the School of Pharmacy in the University of London where, in 1946, an honours degree in pharmacy was instituted which includes in the syllabus for the third and final year a new subject called pharmaceutical engineering science. Recently, the lecturer in this subject, Mr. David Train, B.Sc.(Eng.), Ph.C., explained the development of the need for an engineering training for pharmacists and described the scope of the syllabus before a meeting of the Pharmaceutical Society in London.

In teaching the subject, special attention is concentrated on the movement of materials (*e.g.* fluid flow and properties of particulate matter) and the transfer of energy. In this way, the teaching of unit operations becomes a study of the applications of underlying fundamental principles. It is then a simple step for the student to apply his knowledge of unit operations to the actual manufacturing processes, whether they be concerned with the preparation of a biological product, a synthetic chemical or an antibiotic. Thus, much less emphasis is placed on the details of the manufacture of individual products than has been the case in pharmaceutical education hitherto. The individual unit operations are treated in such a way that the basic principles are developed first. It is only when these have been firmly established that it is demonstrated how the mechanism of the operations and plant conform to these principles. This gives a much firmer and more useful background to the student than would the approach where the manufacturing process is broken down into the individual operations and then an indication is given of the principles on which these operations are based.

Engineers and chemical engineers first criticised the introduction of the new subject in the pharmacy syllabus because they thought it would be taught only in the third year. In fact, the subject is built up in both the first and second years. Throughout, however, the student has the facts illustrated by examples from pharmaceutical practice; thus an essentially pharmaceutical approach is fostered.

At the end, all successful students get a degree in pharmacy and they become pharmacists. There is no claim at all that they are chemical engineers. However, according

to Mr. Train, because so many features of their education are similar to those in the training of an engineer, they can, with the minimum of post-graduate study, become chemical engineers.

Although we doubt if a pharmacist who has studied pharmaceutical engineering in his final year would pass the associate examination of the Institution of Chemical Engineers quite so easily as is implied by Mr. Train, it seems that there should be nothing but commendation for the idea of an engineering training in pharmacy. Any project which spreads knowledge of chemical engineering in Great Britain is praiseworthy. The additional merit of this scheme is that it creates a new source of potential chemical engineers.

New trends in the production of gas and carbonised fuels

CHANGES in the techniques and plant used by the carbonising industries—coking and gas—may be necessary because of a decline in supplies of high grade coking and gas coal. This was predicted by H. D. Greenwood, M.I.Chem.E., at a joint meeting of the Institute of Fuel and the Coke Oven Managers' Association held in London last month. Mr. Greenwood's paper was entitled ' Production of Gas and Carbonised Fuels, Today and Tomorrow,' and he began by pointing out that the coking and gas industries use some 25% of the coal produced in Great Britain. The coking industry, which consists of two main sections—the plants operated by the N.C.B. and by the iron and steel industry respectively—carbonises coal primarily to make metallurgical coke, but the N.C.B. coke oven plants supply in addition some 60% of the coke used by other industries. The gas industry supplies the majority of the coke used by domestic consumers.

The gas industry produces twice as much gas as the coking industry, although carbonising only about 15% more coal. A considerable proportion of the gas produced by the coking industry is used for internal purposes, and the quantity supplied to Area Gas Board represents about 13% of the gas made by the gas industry.

Although both industries undertake high temperature carbonisation, the coking industry obtain their major revenue from coke and the gas industry from gas, and the economics of the two industries differ considerably.

It has been estimated that the output of gas by the gas industry may increase at the rate of about 3% per annum, and this will necessitate the carbonisation of an additional 8 million tons of coal by 1960. To meet the increased requirements of coke for the steel industry and other purposes the coal consumption of the coking industry may increase by about 3 million tons over the same period.

These increased demands for coal may necessitate considerable changes in the present arrangements of coal supplies. There may be insufficient high grade coking and gas coal available, and blending a proportion of lower grade coal will become necessary.

The availability of different grades of carbonisation coals and the new coal price structure may materially affect the future economics of both the gas and coking industries. It may be economic for the gas industry to develop methods of complete gasification which can use coals unsuitable for carbonisation. Much work is being done on this subject both in this country and abroad, and tests on British coals in Lurgi high-pressure gasification plant have recently been carried out.

Over the next few years about a third of the present capacity of the coking industry will have been replaced by new plant, and the present methods of coke production are thus established for some time ahead. The cost of new carbonising plants for both the gas and coking industries has increased very considerably in recent years, but this has to some extent been compensated by relatively lower operating costs due to improved techniques.

The consumption of coke for industrial and domestic consumers (excluding the iron and steel industry) has been increasing at about one-third of a million tons per annum, and corresponding to the increase in gas consumption the availability of coke may continue to increase at a similar rate. It would appear that in view of the shortage of carbonisation coals any larger expansion in the use of carbonised fuel may have to be based on the use of coals which are not normally used for carbonisation, and methods of production of domestic fuels from non-coking coals are being investigated.

The production of smokeless domestic fuels from non-coking coals will involve briquetting, but it may be possible by the use of new techniques, by which the rate of carbonisation can be materially increased, to reduce the costs of the actual carbonisation process. Investigations on new methods of carbonisation are being pursued both here and abroad.

The future of titanium metal

THERE has probably been no metallurgical development in the past five years which has occasioned as much speculation as titanium metal. The underlying reason for this tremendous interest is the unique combination of properties possessed by this new material of construction. Its light weight, high strength and good corrosion resistance have led to its wide evaluation in aircraft, chemical equipment, ordnance and marine structures. According to E. A. Gee, head of du Pont's titanium metal programme, more than 90% of the metal produced to date has been used in aircraft. The outstanding corrosion resistance of titanium in chloride environments has led to numerous field tests in the chemical industry. In salt water, titanium has been phenomenal; after three years of severe marine testing it remains unaffected.

There are many reasons why titanium has not hitherto been produced commercially; these include inability to control the reaction, sensitivity of the metal to gases of the atmosphere, and lack of materials of construction. Notwithstanding these formidable obstacles, titanium output in the U.S. is rising; from the 20,000 lb. produced in 1948, production increased to an estimated 2 million lb. last year and an output of 14 million lb. is forecast by 1955.

The basic problem in the future of titanium metal is the production of low-cost sponge for melting stock, and large sums are being expended by the chemical industry in this field. Drastic reductions in price are essential if a sizeable market is to be won and du Pont alone is spending over $1 million annually in new process research.

Basing his views on advances to date and techniques now under investigation in the laboratory, Mr. Gee predicts a tonnage titanium industry in the foreseeable future.

As reported in CHEMICAL & PROCESS ENGINEERING, December 1952 (p. 681), in Britain Imperial Chemical Industries are pioneering titanium metal production. Following a three-year development programme, the company are now building pilot plants for making wrought titanium and its alloys.

MIXING

Liquid-liquid extraction; continuous agitation; scaling-up data; mixing viscous materials; jet mixing; design of mixers

By D. F. Riley, B.Sc., A.C.G.I.

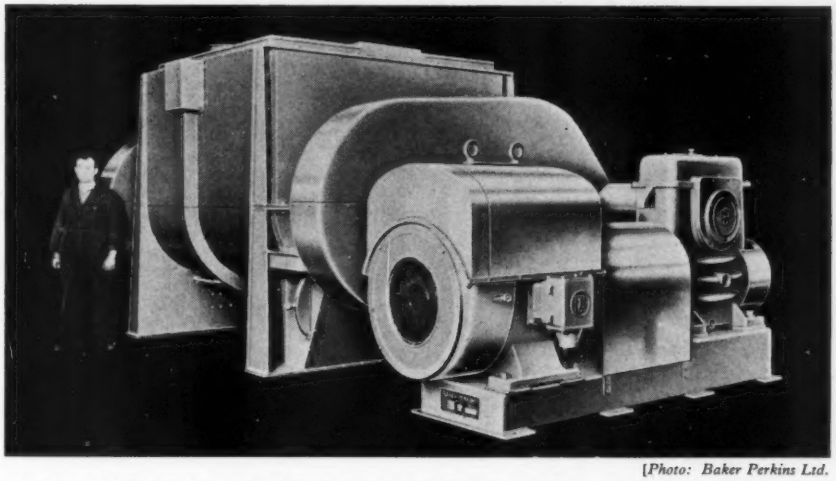
RECENT literature on agitation and mixing published since the last review appeared in this journal (September 1951) has covered a wide range, including papers on continuous agitation, the processing of highly viscous materials, the scaling-up of pilot plant data and the agitation aspects of liquid-liquid extraction.

Liquid-liquid extraction

Performance data on a multi-stage continous extraction column are reported in a paper by Oldshue and Rushton.[1] The column was of glass 6 in. diam. × 36 in. high, having six compartments each provided with four vertical baffles at the wall and agitated by a 2-in. diam. flat-bladed turbine impeller. Separation spaces were included at the top and bottom of the column, but the design was such that there was no provision for settling between the six contact stages. The system used was methyl isobutyl ketone-water-acetic acid, total flow rates up to 4,400 lb./hr.sq.ft. being used and stage efficiencies up to 81% being obtained. Locating the impellers centrally in the compartments was found to give better results than siting them in the openings in the plates separating the compartments. At a given throughput, the H.E.T.S. value was found to decrease as the agitator speed was increased and to pass through a minimum, thereafter increasing until the flooding point was reached. The agitator speeds at the flooding point were determined at various ketone flow rates for a constant water rate, thus delimiting the region of stable operation.

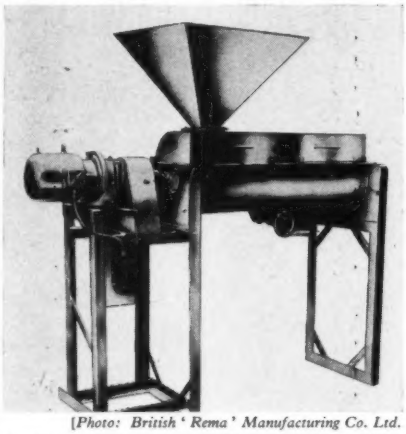
The extraction efficiency of the column increased with increasing throughput until the flooding point was reached, so that it would be desirable to operate such a column at the optimum flow rate as well as at the optimum agitator speed, which in this case lay in the range 300 to 450 r.p.m. Two sizes of opening in the compartment separator plates were used, namely $2\frac{1}{8}$ in. diam. and $3\frac{1}{4}$ in. diam., and at a given flow rate the smaller opening gave considerably better results, although the improvement was partly offset by the necessary reduction in throughput. Some experiments were also conducted with 3-in. diam. impellers, and it was found that the maximum-stage efficiency occurred at a lower turbine speed for the larger impeller, while no significant effect on the H.E.T.S. values was observed. Insufficient data were obtained to allow a conclusive comparison to be made between the power consumption of the two impellers at maximum extraction efficiency.

Garner and Skelland[2] reported work on the rate of diffusion in liquid-liquid extraction which throws light on the velocity and size of droplets it is desirable to produce by agitation in such a process. In an earlier paper, Garner had shown that much higher rates of extraction than those predicted from the film theory based on diffusivity data are obtained when there is circulation within the droplets of the disperse phase and that, contrary to diffusion theory, the rate of extraction is higher from the larger drops. Internal circulation due to the drag of the droplets moving through the continuous phase does not take place under all conditions, but only when a solute is present and when the Reynolds number for the droplet exceeds a certain value. At values of the Reynolds



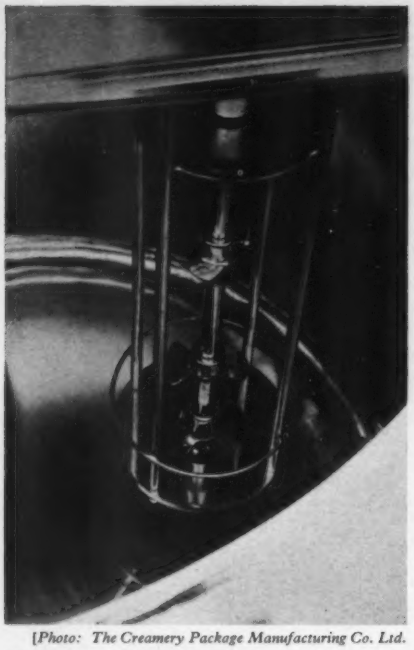
[*Photo: Baker Perkins Ltd.*

'Universal' mixer, for use in the production of carbon electrode paste. The machine takes a batch of 4 to 5 tons and the mixing trough is electrically heated and lined internally with renewable liner plates suitably hardened to resist the abrasive action of the material. The two mixing blades, each of which weighs about 2 tons, can be supplied with adjustable and replaceable hardened steel shoes. Discharge of the mixed material is through motor-operated doors located in the base of the trough. The main drive is from a 100-h.p. motor coupled through a Vulcan Sinclair fluid coupling to a heavy-duty worm reduction gearbox. Switchgear for the main drive and discharge door motors and trough heaters is centralised in a compartment which also houses the temperature control and recording instruments.



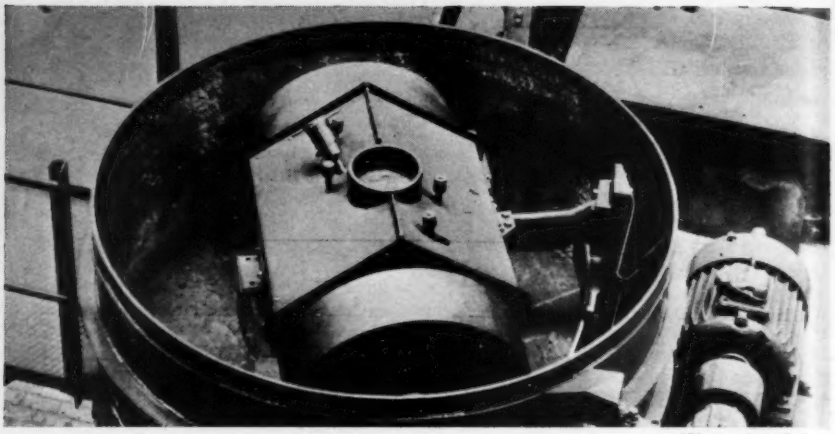
[*Photo: British 'Rema' Manufacturing Co. Ltd.*

A direct-geared contraflow mixer. The mixing element comprises an inner and outer ribbon mounted on a central shaft, carried in dust-tight bearings. The outer ribbons move the material from right to left, and the inner ribbon from left to right, ensuring that the material is given a combined end to end, and turning over movement, which provides quick and intensive mixing. The machine is normally used for dried powders, but liquids can be added to powders providing the ultimate mix is still free flowing. On the smaller size machines the top half of the casing is hinged for easy cleaning and a feed hopper and discharge valve, together with supports to ground level, are provided.



[*Photo: The Creamery Package Manufacturing Co. Ltd.*

The C.P. high-speed agitator. It can be used for ice cream and for mixing materials of a similar consistency. The agitator, it is claimed, gives maximum agitation and a thorough break-up of ingredients. The unit consists of an impeller and shaft, driven by a vertically-mounted motor, which 'draws in' the ingredients and forces them through a mesh strainer. The whole unit can be removed from the motor in a few seconds and is readily dismantled for cleaning.



[*Photo: August's Ltd.*

The 'Mix-Muller' which operates with a 'mulling action' comparable to the rubbing, kneading and smearing action of the mortar and pestle, or the rubbing of a spoon on the side of a mixing bowl. It consists of a circular, stationary pan in which is mounted a combination of ploughs and mullers. The mullers revolve and the ploughs exert a 'shovelling' action to the material being mixed, turning it over upon itself and directing it constantly in front of the mullers. The mullers are adjustable and are mounted on rocker arms so that they are free to 'float' on the material being mixed, creating pressure and an intensive rubbing and smearing action as they revolve, without causing actual grinding. Liquids may be added through a funnel mounted in the centre of the machine without contacting any other part. The material is discharged automatically by the action of the ploughs through a door in the bottom of the pan. The model shown is a No. 2 size (without dust hood), which has an average batch capacity of 12 cu. ft. It is fitted with scraper gear for cleaning the inside of the stationary crib and also the mullers as they revolve. Batch capacities range from 0.1 cu. ft. in the small laboratory size to over 25 cu. ft. in No. 3 size. Charging is carried out either by a bucket loader or by an overhead hopper and batch measurer. The 'Mix-Muller' is used for the mixing of sand and abrasive products, refractories and ceramic material, storage battery paste, welding electrode flux, plastics, food products and feeds.

number below the critical the film theory is applicable and there is no correlation between Reynolds number and rate of extraction. Above the critical value the rate of extraction increases with the Reynolds number and a graph is shown covering the range Re = 90 to 1,200. The more recent work reported by Garner and Skelland was undertaken to determine the factors affecting the critical Reynolds number and it was found that, for a given size droplet, this depended upon the viscosities of the two phases, the interfacial tension and the rate of change of interfacial tension with concentration.

Liquid-liquid extraction is one of several processes which require efficient dispersion of one phase in another, and China[3] has described a type of impeller which has been developed with such applications in mind. It consists of a rotating hollow cylinder having a central hole at the bottom and multiple narrow slots cut around the body of the cylinder. A central baffle plate, in the plane of the axis of rotation, is provided in order to prevent slip of the liquid inside the cylinder. Liquid is thrown out from the slots by centrifugal force, thereby causing liquid to be sucked up into the cylinder through the central hole at the bottom. It is essentially a high-speed agitator designed to produce a high rate of shear in the liquid as it is forced through the slots. As such it is comparable in its field of application with the arrowhead and vaned-disc types of turbine rather than the propeller type of agitator with which qualitative comparisons are made in the paper referred to.

Continuous agitation

With the expansion of the chemical industry and the consequent manufacture of products on an ever-increasing scale, the design of plant for continuous processes becomes correspondingly more important. Even in works where batch processes predominate, however, problems may arise involving continuous agitation as, for example, neutralisation of the works effluent. A number of papers have appeared during the last year or two developing the mathematical theory of continuous flow through a battery of agitated vessels connected in series, but these have been concerned with the prediction of reaction rates and the degree of completion of reaction rather than with the mechanics of the agitation necessary to achieve the desired results. A graphical analysis of the same problem has been given by Jones.[4]

Houston, *et al.*,[5] describe pilot-plant work on the production of fertilisers from rock phosphate involving a four-stage continuous ammoniation section. The tanks were 2 ft. diam. × 4 ft. deep, 10-in. diam. turbines at 200 r.p.m. being used in the first two stages, while 4-in. diam. high-speed propellers were used in the others. Anhydrous gaseous ammonia was passed into each tank through an open-ended sparge pipe, the optimum distribution of ammonia between the four stages being 57, 26, 13 and 4% respectively. As far as the agitation requirements of a full-scale plant are concerned, the results obtained are of limited value, since no baffles were used, thus making accurate reproduction of the flow conditions impossible. In later work on the same problem, Striplin, *et al.*,[6] substituted sulphuric for phosphoric acid and added a second impeller to each of the turbine agitators, the 10-in. impeller being moved up the shaft and a 12-in. diam. impeller added at the bottom, in order to cope with the considerably thicker slurries involved. The same optimum distribution of ammonia between the stages was found.

A paper by MacDonald and Piret[7] reports their work in measuring the effects of agitator speed and flow rate on the time of mixing in a continuously stirred reaction vessel. The measurements of mixing time were made colorimetrically, a small amount of dye being injected into the feed stream, and the results were applied to a study of the continuous hydrolysis of acetic anhydride, which is known to be a first-order reaction. The experiments were conducted in a 2-l. glass autoclave, 4 in. diam., equipped with four vertical baffles, the agitator consisting of four paddles, two of which were $2\frac{1}{4}$ in. diam. It was found that at small feed rates the intensity of agitation controls the mixing time, while as the feed rate is increased the energy of the feed stream contributes increasingly to the turbulence, until there comes a point

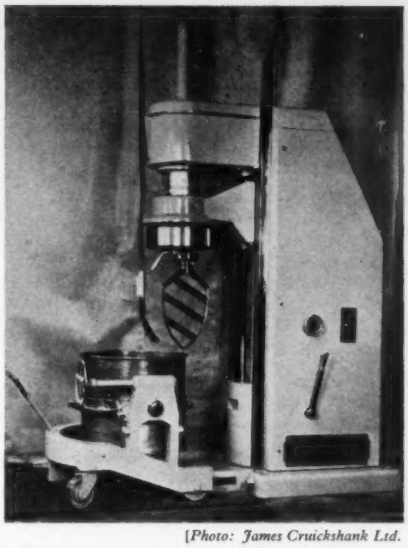
at which the feed rate controls. By plotting mixing time *versus* agitator speed logarithmically, with holding time as the third variable, a family of curves was obtained. Except at the highest feed rates, when agitation had little effect on the mixing time, a break was seen in all the curves at the same agitator speed corresponding to a Reynolds number of 1.04×10^4, this value indicating that fully turbulent conditions had been attained. Below the critical Reynolds number, intense mixing is confined to the region immediately around the impeller and mixing spreads through the rest of the liquid by means of eddy currents formed near the blades, the progress of such currents being controlled by the viscosity of the liquid. Above the critical value, liquid is forced to the sides of the vessel and deflected upwards, thus causing a general turbulence which depends principally on the density and less on the viscosity of the liquid. These observations are in line with the established facts of liquid agitation and confirm results which have been accumulated by various workers on the shape of the curves relating Reynolds number and drag coefficient.

The mixing time was also plotted logarithmically against the total power input from the agitator and liquid stream per unit volume of tank contents, and a straight line was obtained. At low impeller speeds there were random fluctuations of up to $\pm 20\%$ in the concentration of the stream leaving the reactor, but as the speed was increased the deviations lessened and the concentration approached a steady value. The percentage deviation in the experimentally measured degree of completion of hydrolysis from the theoretical degree of completion for a first-order reaction was correlated with the intensity of agitation, expressed as the fraction of holding time required for mixing. On this basis the authors propose that the maintenance, between given limits, of the fluctuations in concentration of the stream leaving a continuous mixer be used as a criterion for judging satisfactory agitation in such a plant.

Scaling-up agitation data

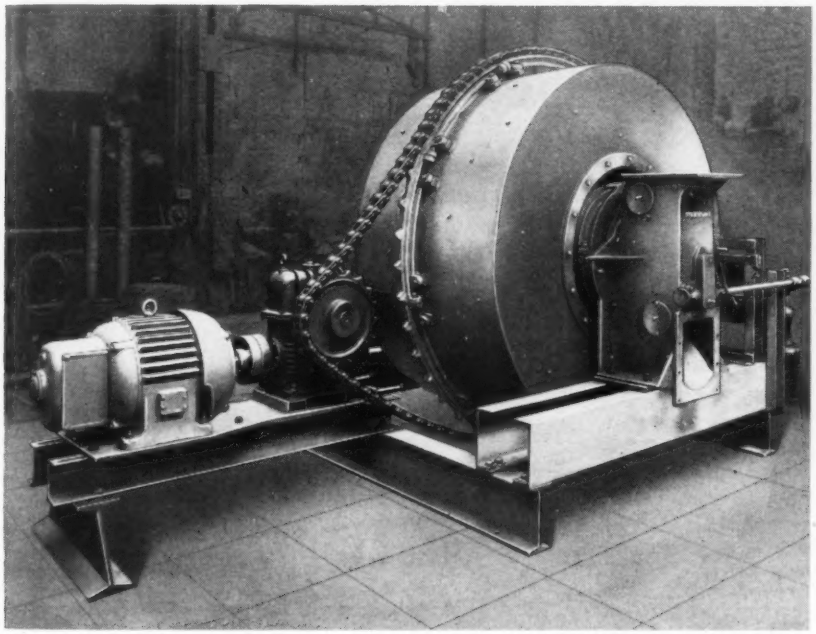
Since agitation data obtained from full-scale plant are rarely available it is frequently desirable, for the design of new plant, to secure model data when the process is at the pilot-plant stage. However, so that the data obtained can be used to predict full-scale performance, certain conditions must be observed. These conditions can be deduced by applying the principle of similitude to the variables involved, a method which has already been used successfully in the fields of fluid dynamics and heat transfer. Dynamically similar motion can be obtained in the model- and full-scale plants without a knowledge of point conditions of velocity and direction of flow, provided the relevant geometrical and force ratios are equal. Depending on the degree of turbulence, the presence or absence of baffles, and whether interfacial tension effects, heat transfer or mass transfer occur, particular dimensionless groups of variables will be involved such as the Reynolds, Froude, Weber, Nusselt, Prandtl and Schmidt numbers.

The factors involved in certain problems of scaling-up have been discussed by Rushton.[8] He considered the case of heat transfer in a baffled agitated vessel under



[*Photo: James Cruickshank Ltd.*

A 200-quart vertical mixer for bakeries and similar concerns. The mixing equipment is detachable from the driving spindle, but, as the complete head withdraws the implements clear of the bowl, it is not necessary to detach these items between mixings. The bowl is mounted on a portable carriage and is fitted with handwheel tilt mechanism, being located and locked during the mixing process. It is also available with a steam or water jacket. Power for the mixing head can be arranged either from a single- or multi-speed electric motor, or by an infinitely variable-speed control unit as illustrated. A clutch is also fitted and is controlled by the vertical lever shown on the illustration. The raising of the mixing head is controlled by push button and limit switch. The planetary head action ensures that all contents of the bowl are thoroughly incorporated and evenly distributed throughout the mixing. To meet demands from the chemical industry this type of mixer is available in capacities up to 70 gal. with either stainless steel or mild steel tinned bowls and equipment.



[*Photo: Sturtevant Engineering Co. Ltd.*

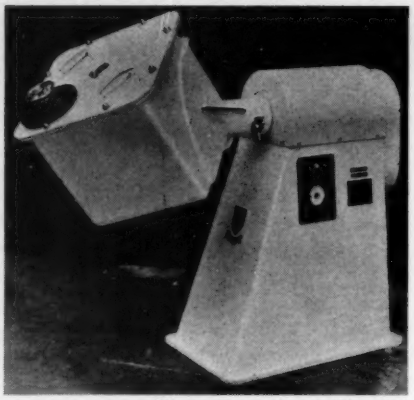
A No. 40 batch blender showing method of driving, which is through a worm reduction gear and chain to a large sprocket secured to the outside of the drum. The machine consists of a continuously revolving cylindrical blending chamber, of large diameter and narrow width, made of heavy mild steel, welded construction, with a smooth interior to which lifter plates are attached. The blending drum is supported at the valve end by a white metal trunnion bearing, and at the opposite end by a heavy steel stub shaft running in a ball or roller bearing carried on a pedestal. The feed and discharge valve is a single unit comprising a pivoted chute and slide, housed in a cast-iron box which faces up to one end of the drum. The machine incorporates a dust-tight manhole at one end and a stuffing box and gland between the rotating drum and the stationary valve box to prevent the emission of dust. The drum and valve box assembly are bolted to a bedframe fabricated from rolled-steel sections. The smooth interior and the design of the internal lifters ensure that all the materials being mixed will empty and a hand-operated lever is used to swing the chute through 90° from the charging to the discharging position, simultaneously operating the slide to uncover the outlet. There are three standard machines made, Nos. 20, 40 and 80, related to the blending capacity, which ranges between 20 to 120 cu. ft., or according to the density of the heaviest ingredient in any batch, approx. from 1,000 to 4,000 lb. per charge.

fully turbulent conditions, using the same liquid at the same temperature, and showed that the ratio of the power requirement on the full scale to that on the pilot scale is equal to $r^{\frac{3-x}{x}}$ where r = scale-up ratio and x = slope of the log Nu *versus* log Re graph. From this it follows that when $x = \frac{3}{4}$ the power per unit volume is the same on the full scale as for the model, regardless of the scale ratio. Thus the common practice of using equal power per unit volume as a criterion for scaling-up agitation problems is shown to be only a rough guide and can, if x is less than $\frac{3}{4}$, lead to serious under-estimation of the power required in a full-scale plant. For low values of x it may, therefore, on occasion, be more economic to use several small units rather than a single large one.

In a later paper, Rushton[9] compares the determination of the force ratios by dimensional analysis with the more fundamental method of derivation from the differential equations for the fluid motion concerned, when these are known. The requirements for dynamic similarity under various conditions are summarised in more detail and systems are considered in which two or more force ratios simultaneously determine the fluid motion. In particular it was shown that, when gravitational as well as viscous forces are present, dynamic similarity requires that the ratio of the kinematic viscosity of the liquids used in the full-scale and model plants respectively is equal to $r^{3/2}$. Since the materials and temperatures used, and therefore the physical properties, are fixed by the chemical process and must be the same for the model as for the full-scale plant, this condition cannot be met and it is desirable to use baffles in the pilot plant in order to eliminate gravitational effects.

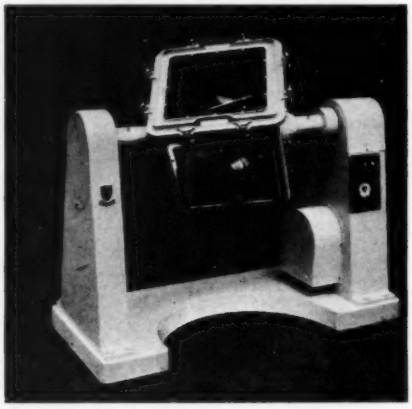
When viscosity is the controlling factor, as in streamline flow, the same flow pattern, but not the same liquid velocities at corresponding points, can be reproduced in different-size systems using the same liquids. On the other hand, under fully turbulent conditions and in the presence of baffles, the same velocities as well as the same flow pattern can be reproduced, since the drag coefficient is then independent of the Reynolds number.

The similarity relations are applied to the scaling-up of gasoline blending tanks using side-entry propellers and to the problem of sizing bottom outlet pipes and determining rates of draw-off from tanks to avoid entraining air as the level falls. Rushton also reports work on the desorption of CO_2 from water to air using a flat-blade turbine in cylindrical tanks, 12 in. and 18 in. diam., with and without baffles. Values of the mass transfer number $\frac{kL}{D}$, where k = film coefficient of mass transfer, L = characteristic linear dimension and D = diffusivity, were plotted against the Reynolds number and it was found that the results for the different size tanks fell on the same line when the tanks were baffled, but on separate lines when the baffles were omitted, thus confirming the predictions based on the principle of similarity. Further unpublished work from the same author's laboratories is concerned with the scaling-up of agitation requirements where heat transfer is involved. Tanks of 12 in. to 48 in. diam. were used, the heat transfer surface being arranged in the form of banks of vertical tubes placed radially from the vessel wall so as to act simultaneously as baffles. Satisfactory correlation of the values of the Nusselt and Reynolds numbers was found, enabling the data to be applied successfully to the design of tanks up to 12 ft. diam.



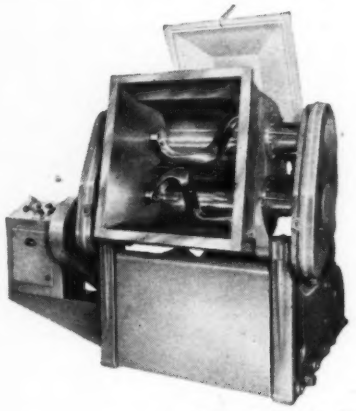
[*Photos: Foster, Yates & Thom Ltd.*

'Rotocube' dry powder mixer. The models shown are *(above)* the No. 2 single pedestal (transportable) type and *(below)* a demonstration model of the No. 2 (transportable) industrial type, showing the impeller unit. Both models have a drum size of 18 in. and a charging capacity of 10 gal. or 100 lb. The 'Rotocube' mixer is used to mix ingredients which vary widely in characteristics and proportions. It consists of a cube-shaped drum mounted diagonally at an angle on trunnions and rotated at a speed of approximately 10 r.p.m. The action inside the drum prevents the heavier ingredients from accumulating at the bottom of the mix and uniformly distributes each constituent. It is claimed that only a short mixing time is required for obtaining the best results. This is said to be achieved without harming the ingredients either through attrition or pulverising, as the mixing action is not dependent on high speeds for its efficiency. Where necessary, impellers can be used (see industrial model). These rotate in the same direction as the drum and combine an 'overturning' motion with the 'interweaving' action. The mixer is discharged either by removing the main lid and 'inching' the drum into the position where two of its sides form a chute, or through a discharge valve set in the lowest corner of the drum. The mixer is electrically driven. The impeller shaft driving gears consist of a driving spur fixed to the end of the drum trunnion, an intermediate compound gear, and a driving spur on the impeller shaft. This train produces a speed contrast between the impeller shaft and the drum of approximately 3 : 1. Five industrial sizes are available with charging capacities ranging from 1 cwt. to 15 cwt.



Mixing viscous materials

The efficient blending of highly viscous, pasty and plastic materials gives rise to some of the most difficult mixing problems, and there is a regrettable dearth of fundamental information on this branch of the subject. Bullock[10] has discussed the factors involved and described some of the commoner types of equipment used, such as kneaders, rolls and mullers. Paste mixing is necessarily limited in batch size, since



[*Photo: Fritz Meili, Zurich*

A Swiss mixing and kneading machine for mixing dry pulverised, fine- and coarse-grained products, as well as for heavy-duty kneading and processing of pasty, liquid, viscous and plastic compounds, including rubber and lead mixtures. It has a working capacity of about 55 gal. and a filling capacity of about 72½ gal. The trough of the machine consists of two connected semi-cylindrical cavities in which the two mixing and kneading arms revolve in opposite directions and at different speeds. The arms are fitted into the trough in such a manner that their action will cover every particle of the material to be processed. All stuffing boxes are fitted into the trough walls independently of the shaft bearings. The mixing and kneading arms are driven from both sides by means of gears hobbed from the solid material. All gears operate in dust-sealed oil-baths. A combination-type electric motor supplies the power. The trough is automatically secured to any position, thus enabling the machine to be maintained in operation even while tilting the trough. This can be closed with a dust-proof hinge cover, fitted to the machine body unconnected with the trough. The machine is the Meili type 250 L.N. British agents are Messrs. E. Frisher, London.

[*Photo: Fordath Engineering Co. Ltd.*

This Fordath 'E' model 'New-Type' mixer is designed primarily for the intensive mixing of foundry silica sands with core binders. The mixing blades are made of cast steel to which are bolted white-iron wearing plates, easily renewable, and a scraper-tip. They rotate in the horizontal plane within the cylindrical mixing chamber. The blades are so shaped that the sand is conveyed from the centre of the pan, rubbed thoroughly against the nine ribbed rubbing plates disposed around the pan wall, forced up the inclined ribs on these rubbing plates and then tumbled back to the centre. After 2 to 3 min. of this action, the entire batch is ready for discharge as a homogeneous, well-aerated mix. The batch is thrust out through the guarded chute when the discharge door is opened. The 'E' model has a batch capacity of 3 cwt. of sand, approximately 4 cu. ft. volume. Drive from the totally enclosed motor is through V-ropes to the fan-cooled worm reduction gear unit. The mixing arms are keyed to the vertical output shaft of the gear unit, on which the pan bottom and mixing chamber are mounted.

the agitator has to be so designed as to reach every part of the mixing vessel. The agitator blades are designed to stretch, compress, fold or shear the pasty material, the speed of the blades being low and the power consumption high. Clearances throughout the vessel must be as small as practicable and, when handling the stiffest materials, the cover of the mixer is shaped to the path of the blades so that the charge is at all times completely confined. The heat generated under such conditions is considerable, and cooling jackets and blades may have to be provided. It may be economical to use one of the lighter types of mixer to pre-blend the less viscous ingredients before incorporating them with the highly viscous materials in a heavy-duty machine. Emphasis is also laid on the advantages of correct preparation of the ingredients and a planned order of addition. If possible, fine powders should be compacted or wetted down with a liquid ingredient in order to expel entrapped air, while materials which tend to aggregate should be broken down by screening or other means before being added to the mixture. Components which are needed in small amounts may sometimes be added in the form of a solution in one of the other ingredients, sprayed into the mixture through a distributor or even as a solution in a volatile solvent which is evaporated off at the end of the mixing cycle. By these and similar means blending times in high-powered heavy-duty machines can be substantially reduced.

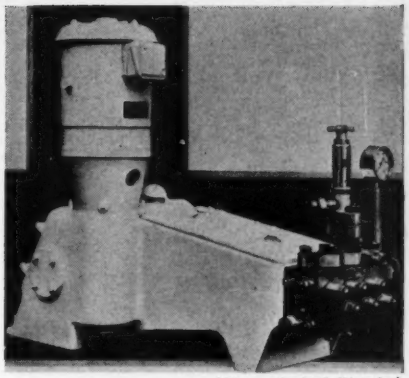
In a study of heat transfer in the processing of viscous materials Perry and Reese[11] give some data on the effect of paddle speed on the temperature control of plastic materials being blended in a paste mixer. Curves are given showing the temperature of the stock as a function of agitator speed and the time of mixing.

Jet mixing

In a recent paper, Rushton[12] points out that high-speed motion photography has confirmed that most of the turbulence in a mixing tank is due to the shear produced by the relative motion of the high-velocity

[*Photo: W. J. Fraser & Co. Ltd.*

In this waltzing paddle mixer an electric motor drives the centre shaft through a variable-speed drive and totally-enclosed worm gear. The centre shaft carries the main frame. As the frame rotates, the planet shafts, which carry the mixer blades, are driven through the planet gears from the centre spur wheel, which remains stationary. This 'waltzing' action gives vertical as well as horizontal motion, thus eliminating stratification. Cast steel is used for the cross-members and paddles. The frame is of forged steel and carries positive scraping gear which sweeps over the whole of the inside surface, to assist heat transfer from the steam or Dowtherm jacket, and to prevent caking. This type of mixer is used in grease manufacture and the variable-speed drive is provided to accommodate thickening of the charge as the reaction proceeds. The finished grease is drawn off through a plug valve at the bottom. This type of mixer, shown above set up for shop testing, can be used for many materials of high viscosity. An interesting feature of the machine is a set of spring-loaded scraper blades which clean the heat transfer surface and avoid a stationary layer.

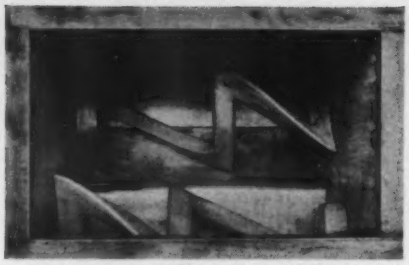


[*Photo: G. & J. Weir Ltd.*

This homogeniser is described as an emulsifier for dairies, ice cream factories, chemical works, etc. The model shown is one of the larger types, driven through worm gearing by a vertical spindle electric motor. This type is made in a range of capacities from 100 to 1,250 gal./hr. The operating principle of the homogeniser is that of a hygienic pump which forces the liquid or paste under treatment through a valve at very high pressure. The regulation of the discharge pressure largely determines the degree of emulsification. The machine is of a horizontal, three-throw type, designed for a steady delivery free from pulsations. The enclosed framing is designed to keep the distance between the plungers to a minimum. These plungers are connected to the pump crossheads by a coupling which allows sufficient radial clearance to render the rams self-aligning, an important factor in machines working at high pressures. Connecting rods, fitted with adjustable large end bushes, transmit the motion to the crossheads, which are of large bearing area and relieve the pump rods of side thrust. The pump discharge is forced across the valve face under the full discharge pressure which is maintained by a heavy spring above the valve.

stream from the impeller and the slow-moving streams from the main body of the liquid. Turbulence arising from surface friction at the walls and from the rapid changes of direction produced by the presence of baffles is of relatively minor significance. The entrainment induced by a fluid jet is discussed in relation to power consumption and figures are quoted to show that, in blending gasoline in a 100-ft. diam. tank, a side-entry propeller moves a greater volume of liquid per unit power than does a circulating pump feeding a nozzle.

Fossett[13] reports some preliminary results of work done on liquid mixing by free jets since the original work on petroleum was published in 1949. Whereas in the earlier experiments the maximum density difference was 6%, data have now been obtained using ethylene dibromide and kerosine, the density difference in this case being 63%. It has been found that the critical excess head is a function not only of the Froude number and the density differential but also of the angle of inclination of the jet. The later work further showed that, for a given density differential and angle of inclination, the Froude number does not always reach a constant



[*Photo: Morton Machine Co. Ltd.*

The 'Z' beater of the new bread-making machine which is claimed to obviate the need for chemical improvers (see p. 86). The mixing container is of a novel and patented design. The side cheeks are made from high-grade cast iron, accurately machined to accommodate the detachable bearing housings for the special 'Z' type beaters. The ¼-in. thick mild steel container sheet is shaped to give a close fit to the machined cheek flanges and securely held in position by a series of bolts of ample dimensions. A ⅜-in. M.S. water jacket is welded to the container sheet and is subjected to a hydraulic pressure test of 50 p.s.i. Suitable inlet and outlet connections are provided. The container is of the 'rigid' or non-tilting type, with a ground and spray-tinned interior. The cover, or lid, seals off the mixing compartment completely and neoprene rubber jointing forms the effective seal. By a single lever action the cover can be slightly raised, allowing it to slide out of the way on rollers in guide rails for full access to the mixing compartment. The beaters and gear wheels are statically balanced and mounted on double row tapered roller bearings of very generous dimensions. Oil seals and packing glands are easily accessible. The beaters are driven at both ends by single helical oil-immersed totally-enclosed gear wheels. The drive to the beaters, from the gear box, is by means of a duplex 1-in. pitch roller chain, encased in an oil-tight casing. Lubrication is by means of a pipeline from an oil pressure pump.

value with increase of critical excess head, as it appeared to do from the earlier results.

Mechanical aspects of mixer design

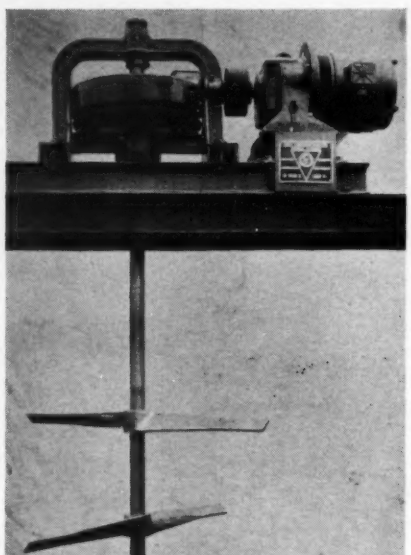
An article by Boutros[14] is concerned with the maintenance of liquid mixers and its bearing on agitator design. Factors involved in determining critical shaft speeds, the design of stuffing boxes and steady bearings, and the installation of side-entry agitators are considered in detail.

Newitt, *et al.*,[15] showed from theoretical considerations that the power required to maintain a solid in suspension in a liquid decreases as the concentration increases. They discussed the effect of baffle location and demonstrated the increased effectiveness, in certain circumstances, to be expected from placing the baffles away from the walls of the vessel.

An alternative type of baffle to the vertical type commonly used for agitators mounted centrally in a cylindrical tank is described by Reavell.[16] It consists of a cross made from flat bar and is either fixed to the bottom of the vessel or raised from the bottom, axially in line with the agitator. Suitable for use with propeller agitators, it converts the rotational component of the flow into a radial one so that vertical motion of the liquid is induced.

REFERENCES

[1]J. Y. Oldshue and J. H. Rushton, *Chem. Eng. Prog.*, 1952, **48**, 297.
[2]F. H. Garner and A. H. P. Skelland, *Trans. I. Chem. E.*, 1951, **29**, 315.
[3]F. J. E. China, *Ind. Chem.*, 1951, **27**, 407.
[4]R. W. Jones, *Chem. Eng. Prog.*, 1951, **47**, 46.
[5]E. C. Houston, *et al.*, *Ind. Eng. Chem.*, 1951, **43**, 2413.
[6]M. M. Striplin, *et al.*, *Ibid.*, 1952, **44**, 236.
[7]R. W. MacDonald and E. L. Piret, *Chem. Eng. Prog.*, 1951, **47**, 363.
[8]J. H. Rushton, *Ibid.*, 485.
[9]*Idem*, *Ibid.*, 1952, **48**, 33, 95.
[10]H. L. Bullock, *Ibid.*, 1951, **47**, 397.
[11]E. Perry and F. E. Reese, *Ibid.*, 354.
[12]J. H. Rushton, *Ind. Eng. Chem.*, 1952, **44**, 2931.
[13]H. Fossett, *Trans. I. Chem. E.*, 1951, **29**, 331.
[14]R. D. Boutros, *Chem. Eng. Prog.*, 1952, **48**, 211.
[15]D. M. Newitt, *et al.*, *Trans. I. Chem. E.*, 1951, **29**, 278.
[16]B. N. Reavell, *Ibid.*, 301.



[*Photo: Apex Construction Ltd.*

A paddle mixer, model 'F,' No. 57, capable of handling 400 gal. of liquor. Built in bronze throughout, it has 3 ft. 6 in. paddles, driven by a 3-h.p. motor through a gear box at a speed of 30 r.p.m. The paddle mixing element operates at low speed, does not require expensive streamlining of vessels, it is claimed, and is useful for dealing with liquids having suspended solids.

Another Apex mixer, suitable for use where solids have to be held in suspension, is the No. 92 propeller type used in chemical and ceramic industries. One typical example is a 5-h.p. model built in bronze, having an 8-ft. shaft carrying a 26-in. bronze propeller revolving at a speed of 180 r.p.m. The propeller mixing element is self-cleaning and can be operated over a wide range of speeds. It is claimed to be an excellent shearing device at high speeds and non-destructive at low speeds. However, the mixer requires careful location and is not suitable for viscous liquids.

Improvement of nickel cracking catalysts

Further improvement of catalysts consisting of nickel on alumina spheres was sought by the Institute of Gas Technology of Chicago, U.S.A., in a research programme described in their Bulletin No. 20. Systematic study was made of the component elements of the catalyst, the support and its porosity, the promoter and its concentration, and the nickel concentration. These variables were first evaluated in screening tests based on the interaction of natural gas and steam at high feed rates, and then selected catalysts were more thoroughly investigated in pilot unit capacity tests.

Ceramic supports

A number of significant findings were disclosed in the course of the work. First, various thermally stable ceramics were found to be suitable supports for the dispersion of nickel in active form. Periclase (fused magnesium oxide) and alumina (fused aluminium oxide) were particularly effective.

Second, addition of small amounts (1.0 to 1.5%) of magnesium oxide or aluminium oxide as promoters greatly enhanced the activity of stable, but relatively low-activity, catalysts. Many other compounds were tested, but none approached the relatively large promoting effects of magnesia or alumina.

Periclase

Third, in a study of periclase supports with porosities ranging from 24 to 52%, activity was found to depend primarily on the quantity of deposited nickel per unit of catalyst volume. Above a value of 4 lb. of nickel per CF of catalyst, additional nickel impregnation had no further effect under the test conditions employed (1,720 to 1,740°F., 3,000 CF/CF cat.-hr. space velocity). The lower-density, higher-porosity supports required a higher weight fraction of nickel at maximum effectiveness. However, the actual weight requirements of catalyst decreased with increasing porosity, in spite of the increasing weight fraction of nickel necessary to maintain a constant amount of nickel per CF catalyst volume.

Laboratory findings confirmed

The data from the pilot unit tests confirmed in a limited way the general nature of the laboratory conclusions and also the limitations in supplying, in a continuous process, the large quantities of heat necessary to effect high rates of conversion. Need for improved process equipment design in continuous tube-type cracking plants, to utilise the higher potential gas-generating capacity of the improved catalists, is indicated. And with these new improved catalysts the use of higher molecular weight hydrocarbons in the cyclic catalytic reforming process will be permissible and advantageous.

Layout, Construction and Equipment of Chemical Factories

AMERICAN AND BRITISH PRACTICES COMPARED

One of the most interesting parts of the Heavy Chemical Productivity Team's report of its tour of the U.S. is the section on buildings, plant and equipment. Here the team discusses expertly American and British practice in factory and plant layout, in the use of constructional materials for buildings and process plants, in the standardisation of materials and equipment, in instrumentation and automatic control, and in materials handling. Below we present extracts from this chapter of the report.*

LAYOUT

The location of factories

IN America we examined the location both of new and of older chemical factories from two points of view—first, had we in Britain anything to learn on the siting of chemical factories and, secondly, had the Americans made the best choice of sites for their own conditions and problems ?

In America the haulage of freight over long distances was often inescapable and freight charges played a much greater part than in Britain in the determination of the site for a factory. We also found that the American was not to be deterred by a shortage of local workers, and was prepared to build whole townships to attract and accommodate new labour. He would also, as we saw, spend as much as 5% of the total capital cost of the factory on piling should the load-bearing properties of the ground be poor.

Disadvantages such as these were, however, offset by many advantages. He had a wider choice than the British manufacturer; he had 30 times more room, longer rivers, canals and seaboards, generally flatter countryside, and little or no statutory obligation to preserve the amenities. Town and Country Planning Acts, River Pollution Acts, Public Health, Factory and Chemical Works Regulations were non-existent or relatively unimportant compared with those in Britain, and the American chemical manufacturer took full advantage of this freedom.

However skilfully the factory was sited to keep freight charges down, there were still relatively high freight charges to face, because nature had not always provided an abundance of raw materials in places where most of the factory's customers insisted on living. Various techniques were used to meet this situation:

(*a*) Capital was spent on the installation of extensive pipelines to convey slurries, liquids or gases rather than to send solids or liquids by road or rail. As an example, a $6-million pipeline was to be laid for 100 miles from Cleveland to transport 7,000 tons/day of coal as a slurry in water. Again, the piping of natural gas and oil over long distances made it no longer essential to locate the manufacture of petrochemicals close to the oil and gas fields.

(*b*) The factory was sited so that bulk transport by water could be used in preference to, or in competition with, road or rail haulage. This, of course, had the further advantages that effluent disposal was easier on a waterway and cooling water was more readily available.

(*c*) Where rail transport had to be used, the factory site was chosen to permit main-line locomotives to enter the factory and do *all* the daily shunting and the site had to permit the free movement within the factory of 50-ton, and even of 100-ton, rail wagons. An attempt was also made to utilise the excellent road system which existed in most of the states, so that road haulage for bulk materials could be competitive.

We found exceptions to this, of course. An electro-chemical factory required a cheap supply of electrical energy and therefore was sited close to a hydroelectric project. Elsewhere a very elaborate Government factory had been for sale and this fact alone had determined the siting of a new chemical undertaking; again, a local owner had wanted a fresh outlet for his coal and for that reason had persuaded others to manufacture chemicals in his area, which was also a strategically safer one in time of war.

There will be nothing very new to the British heavy chemical industry in these observations; in Britain we understand full well what is wanted, but restrictions more frequently prevent the selection of the most economic site.

Factory layout

American practice. Having chosen the site for his factory, the American heavy chemical manufacturer tried, we found, to adhere to the following principles when designing its layout:

(*a*) Offices, laboratories, car parks, canteens and other amenities were often grouped together near the factory entrance; sometimes they were outside the wired-off plant sites so that visitors and non-production workers need not pass through the manufacturing areas.

(*b*) Boiler and power houses were generally to leeward and on the perimeter, but sited so that there were the shortest possible supply lines to the main consuming plants. Where natural gas or fuel oil was used in place of coal, and if fire precautions permitted, the boilers might be sited centrally with the consuming plants around them.

(*c*) Warehouses, tank farms and despatch points were on the perimeter and well away from manufacturing units, but were generally in a line between those units and the factory sidings or road parks.

(*d*) The central maintenance workshops were often near to the boiler and power houses; only very small decentralised workshops, with benches and simple tools, were permitted to be built among the manufacturing units.

(*e*) Railways and roadways were planned to handle very large equipment and vehicles, and to have a minimum number of intersections with each other. Roads had a macadam finish, and were drained to open ditches rather than to closed sewers.

(*f*) Steam, water, electricity and other services were sited on runs which permitted the easiest access for maintenance and for extensions; for this reason it was not common practice to link them into ring mains until the site had been fairly fully developed and major alterations to plant had therefore become infrequent. The underground distribution of services was not favoured and, though we saw both underground and overhead systems, we found that the preferred method was, in most factories, to run services either on timber or steel bridges, or in shallow open trenches. One factory was, however, abandoning the trench system after having experienced a fire which had spread rapidly along a trench from plant to plant.

(*g*) Permanent buildings were usually of steel and brick, but far greater use was made of asbestos sheets, or of bitumastic-covered corrugated iron sheeting, on steel structures for plants which required wind and weather protection. Many plants in the south needed no covering except for control equipment which was placed in brick buildings. Some use was being

**Heavy Chemicals Productivity Report*, British Productivity Council, 1953. 3s. post free. Reviewed in CHEMICAL & PROCESS ENGINEERING, February, pp. 33, 34.

made of prefabricated concrete sections for rapid building construction. In the design of factory buildings we did not find that much care was being given to aesthetic values, except perhaps for main office blocks.

(*h*) Adequate room was available in most factories for expansion adjacent to each parent unit.

British practice. In Britain there will be few to quarrel with these ideas, for many of our newer chemical factories are examples of their application. Perhaps we give more thought to appearance, certainly we cannot often dispense with covering for plants, and it is rare to find main-line locomotives carrying out shunting operations within our factories. We do not think that in factory layout the Americans have much to teach us, but because of the rapid expansion of the American heavy chemical industry we think that there is, in America, a higher percentage of well-laid-out factories than in Britain. For this reason only, it is probably true that good factory layout is making a rather greater contribution to productivity in the American than it does in the British heavy chemical industry.

It would be an advantage in Britain if there were a wider interchange of information on factory layout between those who now have modern factories and those who have still much to do to modernise their works; any modernisation of layout should, in our opinion, use the principles of method study to ensure a really economic solution.

We recommend that the Association of British Chemical Manufacturers should consider how far it would be possible for British heavy chemical factories to interchange experiences, and to pool their knowledge, on factory layout.

Plant layout

Occasionally during our tours of American plants we felt that a better appreciation of the use of height was being shown than in Britain, gravity flow and overhead cranes being used to excellent advantage and maximum value being obtained from the floor space itself. We also noted that the older plants were not so well able to accommodate fork lift trucks as the new ones and this, of course, was true in Britain also. Control panels were popular and it was a common feature to find these located in a clear central space rather than on the perimeter of the plant.

Features of the American plants were the neatness of the lagging and pipe runs and the astonishingly high standard of paintwork everywhere visible. Some of this painting was done by the process operatives themselves, who therefore took a special interest in its preservation; in some factories we were told that they touched it up during odd moments.

Lastly, we *saw* no examples of detailed method study applied to plant layout, and we think it fair to assume that much of the layout was designed, as it had been in Britain, by experienced men using the historical rather than the intensive analytical approach.

MATERIALS OF CONSTRUCTION

Materials for buildings

Flooring. The ground floors of plants were usually of concrete, frequently painted and even waxed to improve their appearance. In Britain, concrete floors made to National Physical Laboratory specifications were found to be giving good resistance to ground corrosion, but these specifications were not met with in America. Some American workshops had wood floors to minimise damage to things dropped.

Platforms and stairways were of conventional construction of steel and chequered plate or of fireproofed timber. In one factory the stair treads were of a 2 in. × 1 in. diamond mesh in $\frac{1}{4}$-in. square mild steel, and the flooring of platforms was of a 1-in. square mesh of $\frac{1}{4}$-in. round. Both appeared to be satisfactory, advantages being improved ventilation, a non-skid surface and an economy in the use of steel; on the other hand, any open flooring can be a hazard to those below. Portable stools for extra reach locally were neatly made from scrap 1-in. piping with steel of similar mesh welded on.

Walls. Plant walls were sometimes of rough hollow concrete blocks of dimensions 16 in. × 8 in. × 8 in.; it was claimed that these gave good insulation and were as cheap to erect as steel and asbestos walls, which also were preferred to brickwork because of the high labour cost of bricklaying in America. Some side walls were designed for ease of removal in very hot weather.

Doors and windows. Sliding steel doors were common, but in one American factory the hanger rail was placed on a slight slope and the door counterbalanced with a weight for ease of opening. Windows, as in Britain, were frequently too high for easy cleaning and no access to them was provided. As a result they were often rather dirty and so the electric lighting system had to be left in use in the day-time. It was surprising how little attention was given to this in either country.

Ceilings. Porous white tiles were very often used for sound insulation on the underside of ceilings in office and amenity blocks. They were occasionally seen in Britain, but their use could well be extended to reduce distraction by noise.

Heating, lighting and ventilation. In the hot south and west some plant buildings and most offices and amenity blocks were air-conditioned very effectively; elsewhere heating and ventilating systems were conventional and often very good as far as we could judge. Much use was made of fluorescent lighting, not only in offices but also in plant control rooms. One plant was equipped throughout with screw-in type mercury vapour lamps which, though expensive to install, were economical in power consumption. Yard lighting in one factory was from groups of very high-powered electric lamp bulbs set round exceptionally tall masts; in others the conventional road lighting seen in Britain was common.

Painting. In most factories a standard of painting far higher than in Britain was accepted as essential to good housekeeping. Bitumen-based plastic undercoats were finding favour and were also used for the protection of lagging. Lagging was extremely neat, partly because leakages from flanges were rare, most pipe runs being welded. Much of the equipment was clearly marked with the date of last painting and with a code number which enabled the type of paint and the method of application to be ascertained. Little use, however, was made of colour coding to indicate the contents of pipelines.

Materials for process units

Most of the American companies maintained a specialist department responsible for the selection and testing of materials of construction, and these departments circulated information bulletins to users. Laboratory and corrosion tests were generally accepted as valuable only for ruling out obviously unserviceable materials. Pilot-plant trials of materials which had passed the laboratory tests were often conducted as near to the site of the process plant as possible and, indeed, on the site in some factories.

We shall deal here only with the use of stainless steel, cast iron and enamel, and with welding techniques. For additional details of American practice we would refer to a recent specialist survey.*

Stainless steel. Having seen stainless-steel trains, coffee bars and even new office blocks, we realised that the American industrialists' complaints of shortages of this—in Britain—precious material, were not unlike those of the small girl who was not allowed to *finish* the box of chocolates. Certainly the rearmament drive had made it harder to obtain the grades stabilised with columbium and with molybdenum for chemical plant construction, but the former were still widely used and Government permits for the latter could be obtained. Titanium-stabilised steel had not been extensively tried, extra low carbon steels with little or no columbium or titanium stabilisers having been found suitable for many corrosive conditions.

Cladding with stainless steel was viewed with suspicion, though in some factories it was considered adequate for storage vessels, and in others a thickness of $\frac{3}{16}$ in. was specified if welding was necessary. Solid stainless-steel vessels were considered to be more economical up to 15,000 gal. capacity than clad vessels. In one factory mild steel had been used to replace stainless

**Chemical Apparatus in the U.S.A.* Reviewed in CHEMICAL & PROCESS ENGINEERING, September, 1952, pp. 486-488.

steel to avoid high capital expenditure, although it was realised that repairs would be more frequent.

Cast iron. Cast iron was still widely used in chemical and auxiliary plant. We saw how two cast-iron compressor cylinders, which had been badly cracked by misuse of the compressor, had been repaired at half the cost of replacement, and to the satisfaction of the insurance company, by lacing the broken faces together and plugging the crack. Specialists in this technique are now available in Britain and we mention it because the repair had been completed in two weeks, whereas a replacement in Britain might not have been available for a year.

High-silicon irons, though brittle, have excellent resistance to acid and salt solutions and were used to some extent as castings for pipes, valves and pumps, but we believe that many applications to which these irons would have been put in the past were now covered by the use in America of stainless steels.

Enamel (or glass) lining. We saw enamelled steel reaction vessels of 3,000 gal. capacity which were giving satisfaction, but emphasis was laid on the importance of training all concerned in the proper handling of such equipment. A method of repair in case of enamel failure, by the use of tantalum plugs or sheets, was seen and has also been described in Britain, though we believe it is not widely known in this country.

Welding. Welding has been the subject of a separate Productivity Team Report; we would only add that one American chemical firm insisted that each of its welders should pass a test of ability in a standardised welding technique, and thereafter stamp his own identification mark on each weld. We thought this to be an excellent practice.

In one plant we saw aluminium and certain stainless steels being welded by the argon shielded arc method.

Much use of butt welding was made on pipe runs in place of the screwed joint common in Britain; both flanges and leakages were fewer, and lagging could subsequently be applied more neatly.

There is no doubt that the proper selection of constructional materials can have a marked effect on productivity and, indeed, one American chemical firm particularly stressed that this had made a substantial contribution to theirs. But in general we felt that the British heavy chemical industry, though very short of certain materials, had little to learn from the American in this matter.

Standardisation of materials and equipment

An important method of increasing productivity is to reduce to a minimum the *variety* of materials, equipment and products with which a factory is concerned, and then to standardise them. The result can be quicker delivery of materials and a great saving in the capital tied up in idle stocks. This in turn permits reductions in the amount of storage space and in the services of storemen and clerks, and there is a saving in production time because maintenance and change-over delays are reduced, and less time need be devoted to detailed design and to training. However, it is not often possible to standardise in this way until a new process or operation has reached a fairly advanced stage of development and, even then, supplies of the preferred materials and equipment may not readily be forthcoming.

American practice. In America we found the following examples of standardisation of materials and equipment:

(*a*) The National Electrical Manufacturers' Association had agreed standards for electrical equipment; for instance, all electric motors of a given horsepower, irrespective of the manufacturer, had the same size of frame and were completely interchangeable; interchangeable plugs and sockets had also been widely standardised for electrical equipment.

(*b*) The American Society for Testing of Materials had set up specifications for stainless steels, and every sheet delivered from the mills was stamped with a code which had been accepted on a nation-wide basis. Thus if an American chemical manufacturer required 18/8/$1\frac{1}{2}$-$2\frac{1}{2}$ Mo stainless steel, he ordered Grade 316 and knew that the composition could be relied upon irrespective of the supplier; this coding also obviated subsequent errors in his own factory stores. It is true that two of the American factories visited also tested every piece of constructional material received, but other factories where this was not done said that they had found no need for such a check.

(*c*) A Chemical Industry Correlating Committee had been formed by chemical firms and equipment manufacturers to advise the American Standards Association on standard specifications for chemical equipment; this Committee had already advised on standard valves and tubing made from stainless steel and these standards had been adopted by the manufacturers. In our view, the Committee will become of great value to the American industry.

However, we do not think that the standardisation of constructional materials can, in either country, be a short-term policy for increasing productivity. There is too much valuable non-standard equipment in use, and there must always be a danger of over-standardisation which might retard the rate of improvement of design. We found that American executives were well aware of this danger and some chemical firms had given their technical staff a very free hand to experiment with non-standard equipment. However, where standardisation was the creed we found that spares had been reduced to as little as 1.25% of the total capital investment, whereas in other factories of the same companies they averaged about 3%. One American firm bought its main equipment in the cheapest grade of stainless steel that was likely to be serviceable (perhaps 18/8—Grade 304), but insisted on Grade 316 for spares despite its 10% extra cost, the argument being that if a part failed then its replacement by the more expensive material was probably inevitable and the advantage of having all the *spares* to standard simplified storekeeping.

We were surprised to find little evidence in America of the standardisation of testing procedures for chemical equipment, and we felt that Britain was probably ahead in this respect.

British practice. In Britain it is well known that manufacturers of motor car, machine tool and aircraft components, and electrical equipment have made very good progress in standardisation, partly through the Engineering Equipment Users' Association and partly through the British Standards Institution. In the chemical industry, and despite the difficult delivery position, some of the larger British firms had their own excellent standards departments for constructional materials and equipment, but there was not the same *national* progress as was apparent in America.

We know that the Association of British Chemical Manufacturers and the makers and users of chemical plant equipment and constructional materials have, over the last 30 years, considered the simplification and standardisation of their ranges and dimensions. **We recommend that this effort be intensified and also that British chemical manufacturers should note the American policy of buying mass-produced unit equipment in preference to fabricating their own.**

INSTRUMENTATION AND AUTOMATIC CONTROL

Policy

We found that the Americans had a keener appreciation than the British of the advantages of instrumentation and automatic control for chemical process work—maybe because of the higher cost of labour, maybe because of the earlier influence of these developments in the oil industry, or even perhaps because of the rapid expansion in America of continuous rather than of batch processes. The Americans saw clearly that proper instrumentation, coupled where practicable with automatic control, often made possible a *uniformity* of process operation which itself reduced costs, improved material efficiency and yielded a more uniform product. In America this uniformity of operation was the main justification for instrumentation, and saving of labour was regarded as of secondary importance.

Of all the American factories visited we found that only one showed little appreciation of these points; 35% of the American factories favoured full instrumentation and maximum automatic control—these were generally factories operating continuous

processes which could not well have been controlled by hand; 60% favoured instrumentation for recording purposes, but preferred hand control so that the operator's interest in and knowledge of the plant would be maintained. In one factory using maximum automatic control it was the rule that full hand control be used for one hour a week so that the operators would be prepared for any emergency.

Only about 15% of all these factories insisted on previous economic justification for new instruments, one firm stating that an instrument must pay for itself within six months. Operators generally welcomed instrumentation as a natural development which increased the status of the job; no doubt this attitude was conditioned in part by the relative newness of many of the American factories, by the system of training of the operators—to whom the advantages of instrumentation and of automatic control were carefully explained—and by the policy of fostering a sense of security of employment among the trained men.

Training

America has been well ahead of Britain in the dissemination of specialist knowledge on instrumentation; in the late 1920s there was an American monthly technical journal devoted to instrumentation and automatic control, and in the early 1940s it was possible to obtain this training in many American universities and technical colleges. In British such a journal has been published for several years and three instrument organisations are now encouraging education in instrument work. Recently, specialised instruction has also become available in the British universities and technical colleges. We believe that our instrument industry is technically as capable as the American, but that in education and training in instrumentation we are still well behind.

In America men for training in instrument maintenance were commonly drawn from other departments of the same factory, using the 'helper' system already described. One company preferred to take men with process experience, claiming that it was of first importance to have instrument men with a knowledge of process control. Training was by lecture and by practical work in the shop, in addition to carrying out duties as helpers to experienced mechanics. One firm gave a course of 720 hours' general training of this type; another spread the training over a four-year period and held an examination at the end of each year. Men under training were also sent to instrument manufacturers' works, but much of the initiative to make good was left to the man himself, and we heard of one case of the men privately organising their own classes in electronics.

In Britain it was the practice to work a formal apprenticeship as an instrument mechanic from the age of 16, and several chemical companies had their own apprentice training facilities and also made use of the facilities offered by the instrument manufacturers. Some men from other trades also took training as instrument mechanics. There were also part-time courses, covering a five-year period, for the City and Guilds Examination for Instrument Maintenance Mechanics and, where the supply of students was adequate, these courses could be obtained at technical colleges—local firms often assisting with the services of lecturers.

Nevertheless, we feel that much more must be done, and we recommend that the Association of British Chemical Manufacturers should explore, with the Scientific Instrument Manufacturers' Association of Great Britain Ltd., the British Industrial Measuring and Control Apparatus Manufacturers' Association, and the Society of Instrument Technology, whether the needs of the heavy chemical industry, particularly in training, but also in instrumentation service, could be more fully met. We also recommend that British chemical firms consider the possibility of releasing young chemical engineers or chemists with plant experience for further university education in instrumentation and automatic control.

The instrument department and the instrument maker

The American instrument department was often split into at least two sections, one dealing with instrument maintenance and the other with the development of new instruments or new uses for instruments. This latter section was of special value in ensuring that the best choice of instruments was made. In 13 of the factories visited these departments were under the works engineering staff, but in the other two they were under the control of production staff.

In America the average instrument department had two maintenance engineers and 12 instrument mechanics who serviced some 1,500 major instruments, but these figures were rather misleading because the American instrument departments contracted out practically all their fitting and electrical installation work to other departments; also some routine work such as changing charts and inking pens was usually left to process workers.

In Britain the average department had one instrument engineer and 17 mechanics who serviced some 500 instruments, but who generally did their own fitting and electrical work as well. The American superiority in technical graduate strength and in the extent of instrumentation in the average factory will be noted.

We believe, too, that there was a greater competitive spirit between the numerous American instrument manufacturers, with the result that any call for aid was met with very keen service; this particularly applied to the development of automatic controls, and we heard many stories of makers' representatives travelling long distances at short notice and staying on the job until problems were solved.

However, the American instrument manufacturer, though keen to develop new instruments, was also keen on long production runs, and discouraged short runs on specialities by realistic costing.

The smaller American chemical firms depended considerably on the instrument manufacturers' service and generally only had small instrument departments in their own works.

In Britain we were told that some instrument makers' services were good, but that delays in the provision of equipment were often longer than in America. On the other hand, the view was recently expressed that British users of automatic control equipment did not take full advantage of the advice and service now available from the manufacturers.

Instrument practice

Graphic panels. In America there was a tendency to use miniature instruments or graphic panels on the more highly instrumented plants, the recording and indicating instruments of lesser importance being mounted on neighbouring sections of a central panel. The instruments on these graphic panels, though requiring less space, were about 25% more expensive than standard instruments. Graphic panels, though looking well and possibly helping in the training of new operators, had the disadvantage that their layout was designed to emphasise the flow diagram rather than for ease of operation and maintenance; these panels were costly to alter when changes were made in the process. We did not see many in use, and opinion on their merits was divided, as we believe it was also in Britain.

Centralised control. Large central control panels were often found on continuous processes. However, in about half the factories visited smaller decentralised panels or isolated instruments were sited close to the units, and it was then generally clear that fully centralised control would not have been of advantage. Where control was fully automatic it was claimed that products of the right quality could not have been produced, except by the employment of more operators (or, in some instances, even of many more operators).

Batch processes. Instrumentation and automatic control had not been developed for batch processes to the same extent, though we saw in both countries automatic weighing and measuring of charges, and some automatic control of batch conditions.

In the laboratories. Instruments were being increasingly used in America for laboratory control work, and one firm said that it had been able to reduce its routine analytical staff from 62 to 35 during the last four years largely by this means.

Conclusions

We found that there was but little attempt to standardise on types of instruments, whether electronic or pneumatic, no doubt because it was fully appreciated that there was still much room for improvement both in design and in application. But in America there was a greater confidence, particularly in automatic control instruments, than was usual in Britain; maybe this was because in the past British control instruments had not always proved reliable or been properly selected, or because we in Britain were so short of experienced instrument maintenance engineers and designers.

We are bound to conclude that the American heavy chemical industry made fuller use of instrumentation and of automatic control, had a greater technical strength, and also a somewhat better repair service from their instrument manufacturers. In our view these factors were contributing much to the productivity of the American heavy chemical industry, in particular by improving materials efficiency and the uniformity of chemical products.

MATERIALS HANDLING

It is well known that American industry makes much use of mechanical aids when handling materials and we found that this was true of the heavy chemical industry, *but in the American factories visited we saw no materials handling equipment which could not be obtained in Britain*—just more of it. Treble or quadruple handling of raw materials, common in Britain, had in many factories been reduced to double handling by *bulk* unloading of ships or barges direct to works stock, using grabs for solids, or pneumatic conveyors for 'powders,' and pumps for slurries and liquids. Pallets and pallet trucks of various types were widely used, not only when handling raw materials and products but also for bricks and other structural materials. Workshops were fully equipped with cranes, jibs and monorails.

The Americans were, of course, rather contemptuous of our 'midget' 10- and 13-ton railwagons; after watching 2-cwt. bags being loaded by an articulated conveyor into their 50-ton box cars, sulphuric acid and 50% caustic soda filled into 55-ton and even 70-ton rail tanks, and liquid chlorine into 50-ton rail tanks, we had to admit that in Britain our methods required not only more labour but also more steel per ton of product handled. Certainly in Britain we used 40-ton rail tanks for caustic soda and there were 50-ton hopper wagons for some raw materials, but these were not commonly to be seen on our factory sidings.

Much of this has been discussed already in two recent productivity team reports* and our first recommendation to the British heavy chemical industry is that these reports should be read carefully, for we are doubtful whether they have yet been studied by many of the technical staff in our industry. Nor is there any reason why our local union officials, who could do much to bring these reports to the consideration of their members, should leave this entirely to management; we think the unions could do much to secure better working conditions by encouraging the right use of bulk handling and of power to replace brawn.

Our second recommendation is that materials handling equipment should be chosen with extreme care, and preferably after a detailed method study of the process affected, for we have seen equipment installed, both in America and in Britain, which had later proved unsuitable or uneconomic for particular operations. For this reason we suggest that each British chemical firm should select one or more members of its technical staff to make a special study of available equipment, and to carry out a survey of the whole factory, so that the co-ordination of possible uses for mobile equipment, and the peculiar requirements of the factory for equipment which will withstand corrosion and which can be standardised for maintenance, will be properly considered. If this work is left to individuals who have no specialised knowledge of available alternatives, and who are harassed by the pressure of other duties, there is not likely to be much progress beyond a turning over of catalogue pages and the ordering of a few mobile cranes.

After the initial survey, arrangements then need to be made for a continuous study of the changing requirements of the factory, otherwise progress in materials handling will be disappointing.

It has been said that the handling of materials generally accounts for anything from 15% to 85% of the cost of production. It would be a simple matter for each factory to determine its figure, and we are confident that this would reveal the importance of tackling the problem without delay.

By a concentration on improvements in materials handling techniques we envisage 50% to 100% increases in labour productivity in those parts of a chemical factory where materials handling is a major operation.

**Freight Handling; Materials Handling.*

Practical problems of glue and gelatin manufacture

Practical questions about the main processes of the glue and gelatin industry were discussed for the first time at a meeting of the Research Panel of the British Gelatin and Glue Research Association held in London recently. A number of plant manufacturers attended the meeting.

The first paper was given by Dr. W. E. Braybrooks, of Stokes & Co. Ltd., with the title 'Tannery Treatment of Pieces and Fleshings.' He described the tannery processes which precede the despatch of waste material, pieces, split hides and fleshings to the gelatin or glue works, and outlined the reasons for the use of different processes. He outlined the effect on the hide of short dehairing processes using strong sulphide solutions in addition to lime, as compared with the slower-acting lime treatments which may have small sulphide additions. He also considered the use of drum dehairing and liming in comparison with pit liming, with or without agitation.

In the second paper, 'The Extraction of Hides,' Mr. D. Fysh, of the Association's staff, described small-scale experiments on gelatin production. The principle variables considered were period of pretreatment of the raw material with lime suspensions, time, temperature and *p*H of extraction, solid/liquid ratio in extraction and the effect of added salts. In each instance, rate of extraction and the quality of the product were determined. The method of extraction followed the works process in carrying extraction virtually to completion, by using five successive operations of increasing severity. In this, the work was an advance over the earlier investigations of R. H. Bogue and W. M. Ames.

The third paper was by Mr. D. B. Hall, of John Knight Ltd., and was entitled 'Bones Processing.' Mr. Hall commenced by describing the nature and mode of collection of the industry's raw material. He then followed the process stage by stage to the point at which the dilute glue liquors are ready for evaporation. At each stage he commented on the method of operation of the plant and on the problems which arise.

The final paper, by Dr. E. M. Vyner, Sheppy Glue & Chemical Works Ltd., described the evaporation and drying of gelatin and bone glue liquors under the title 'Aspects of the Evaporating and Drying Process in the Glue and Gelatin Industry.' Dr. Vyner outlined the principles of drying and discussed the main actual and potential methods of going from a dilute gelatin or glue solution to the dry material. These included spray drying, freeze drying, single and multi-effect evaporators with or without thermal recompression, low-temperature (ammonia) evaporators, the various means of producing subdivided jellies for the final stages of drying, and drying tunnels or batch driers. The ideal was stated of a single economical process giving a conveniently sized end product for use. No process at present in operation conforms entirely to this ideal.

Discussions followed the reading of each paper.

CENTRIFUGING

Hydroextraction; centrifuge performance; new machines; applications—sugar, fermentation, oils and fats, petroleum, chemicals

By E. Broadwell

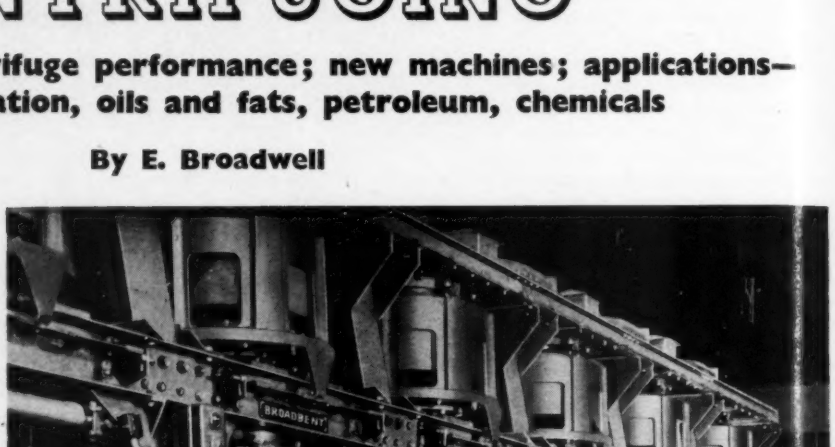
Hydroextraction

THE most interesting fundamental work published recently[1] describes a further study of (*a*) the measurement of flow conditions in hydroextractors, (*b*) the relationship between the permeability of cakes formed in hydroextractors and those produced under hydrostatic conditions and (*c*) a method for the measurement of permeability based on drainage time when other methods are not practical. From previous work, flow rate equations had been developed and for (*a*) these were tested using methods based on different functions deduced from the equations and also employing a number of variables. From the results it was generally concluded that the proposed equations gave a near-truth representation of the mechanism and flow relationship.

Discrepancies in permeability previously observed in (*b*) were investigated and it was concluded that the visual detection of the critical wetting rate and the liquid level on the cake at low permeabilities contributed to the errors. This was further verified and results show such agreement that no modification would be necessary to the proposed flow equations for hydroextraction. One of the more simple and readily applicable methods used in (*a*) for the measurement of permeability is based on the drainage rate for a given volume of liquor. This was applied to four different types of solid in the case of (*c*) and the data are expressed in a number of ways; it is shown that such a method is reasonably accurate, more so for low permeability materials, and it may well be applied as a general method for evaluating equipment of this type.

Centrifuge performance

Some mathematical relationships are developed by Ambler in a paper dealing with centrifuge performance.[2] Two expressions are obtained which relate (*a*) the factors involved in the liquid under test and (*b*) those appertaining to the centrifuge; the latter expression represents a gravity settling tank of equivalent capacity to the centrifuge. The expressions are extended to cover tubular and disc-type bowls; for the practical evaluation of such machines it is necessary to know accurately the particle size of the material to be separated and in industrial problems this is usually impossible to ascertain. It is stated that under the circumstances it is necessary to resort to small-scale tests and an 'experience factor' has to be introduced before results on commercial machines can be predicted. In continuously discharging types of machines the condition of the solids introduces another variable and it is usually necessary to resort to full-scale tests. The paper goes on to describe the various commercial machines made by the Sharples Corporation and their suitability and limitations for general application are discussed, together with the information required for the selection of the most suitable unit.



[*Photo: Broadbent & Sons Ltd.*

Battery of sugar centrifugals fitted with 'Poppleton' type baskets with automatic discharge valves.

The book, 'Chemical Engineering Operations,' has a section on centrifuges[3] and a short review of the subject covering a wide field has been published in America[4]; another brief review describes the development and application of Broadbent machines for food and other industries.[5] A revised B.S.S. for hydroextractors and centrifugal machines operating at speeds of 400 to 3,000 r.p.m. has been announced[6]; the calculation of stresses has been simplified and information is given on the materials of construction necessary for modern requirements.

An attempt has been made to correlate information involving costs and performance of the various types of centrifugal machines available in the U.S.A.[7] In the reviewer's opinion, however, except for the more standard applications of basket-type machines, the information is far too general in character to be of much value. Further estimates of maintenance costs for basket and continuous horizontal centrifugals are given.[8]

Laboratory machines and new applications

No new laboratory machines have been offered recently, but a short description of

an ultracentrifuge suitable for operation under very high vacuum is of interest.[9] It is driven by an air turbine and is designed to run for several days, a necessity when determining molecular weights, by the sedimentation equilibrium method, of high molecular weight materials. Another announcement in the ultracentrifuge field describes a new batch-type bowl suitable for spinning 1,600 ml. of liquid under controlled temperature conditions at 20,000 r.p.m. (centrifugal force 16,770 to 43,380 times gravity).[10, 11] The present available types of laboratory centrifuges which are particularly suitable for the paint industry have been usefully summarised.[12]

Among the more unusual uses of laboratory machines is the separation of tar from samples of road surfacing materials.[13] The estimation of particle size by centrifuging has been given further study and an interesting account[14] gives details of the method and the theory involved. Other centrifugal methods developed for more rapid analysis of samples include the estimation of acetone-insoluble foots in crude soya-bean oil,[15] lead as lead sulphate in lead dross and similar materials,[16] and pentane and benzene insolubles in used detergent and non-detergent lubricating oils.[17]

New industrial machines

Some further information on the principles and performance of the Luwesta extractor has been published.[18, 19, 133] It consists basically of three disc-type bowls in one shell and its main use is for countercurrent extraction; the liquids are mixed by means of a spray disc in the first stage and after separation are simultaneously collected and mixed by single skimming discs in the other two stages. The maximum total liquid throughput (not necessarily operating capacity) is approximately 1,100 gal./hr. and the machine has a power consumption of 12 kw.; the bowl has a speed of 3,800 r.p.m., a diameter of 21 in. and a solid holding space of 4.7 gal. Some performance data for the recovery of acetic acid in the manufacture of cellulose acetate and the extraction of penicillin from broth are given, together with a list of potential applications.

A newly designed range of centre-slung basket centrifugals for the chemical industries is obtainable in the U.S.A.[20] Some general information on Rheineveld horizontal machines has been published.[21] Two patents[22, 23] cover perforated basket-type machines fitted with rotary feed screws operating intermittently for the continuous discharge of solids under controlled conditions and a further patent relates to an improved construction for self-washing cream separators.[24]

Sugar

Among the machines developed for this industry the new Broadbent high-production unit has proved to be extremely satisfactory in operation; two installations have been described,[5, 25] one for cane and the other for beet sugar. The common feature is the use of *Poppleton* baskets which are fitted with a pneumatically-operated bottom discharge valve working automatically with the plough. Both installations are good examples of how automatic control can be utilised to good effect and this is reflected in the typical performance data which are quoted. Although not a new machine, the use of the Escher Wyss model C.4 in this industry is a fresh application.[26] This machine has a horizontal basket fitted with a hydraulic pusher operating continuously which gradually moves the crystals towards the basket lip. Provision is made for washing and leading off the washings separately; some details regarding their operation are given.

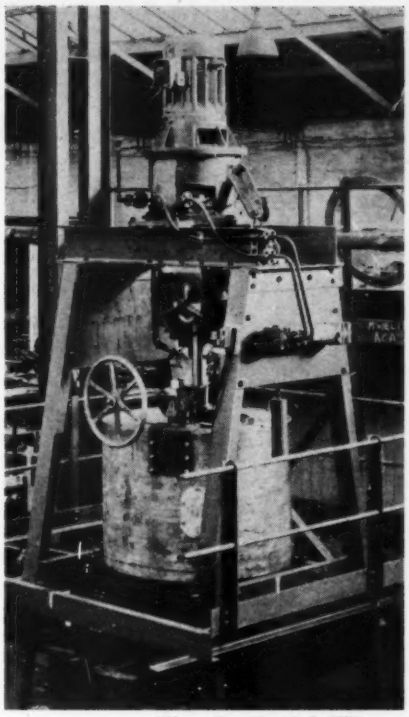
Another battery of new automatic basket machines has successfully completed a season's operation; an abstract gives some information about their features and performance.[27] A patent relates to a new design of machine fitted with a stripper, which, by moving the basket towards the stripper, results in a discharge of sugar crystals over the basket lip.[28]

Some of the recent improvements and requirements in design of high-speed basket centrifugals has been summarised by Tromp.[29] Observations on the bowl speed in relation to the peripheral speed and centrifugal force developed for different diameter bowls are presented graphically, with an illustration showing how the pressure on the bowl wall is affected by the depth of massecuite layer.

In a paper dealing with the safety of centrifugal baskets in this industry,[30] it is stated that when formulæ for the determination of the safety factor are applied to most modern high-speed machines, a product below unity results and fatigue will eventually cause the basket to fail; it is suggested that comprehensive tests be undertaken to increase this factor. In another paper on this topic,[31] the reasons for failure and indications of approaching failure are well defined and suggestions for preventive maintenance are given. This information should be of general interest to all users of equipment subjected to cyclic stress. Other maintenance tests for sugar centrifugals have been outlined,[32] but due to the present trend of design and the varying processing requirements no general rules can be applied.

Further information published refers to the re-melt centrifugals employed in a British refinery[33]; Java practice with special reference to final molasses[34]; the use of a nozzle-type centrifuge for the clarification of partly filtered raw juice by removing mud[35]; the proposed use of a machine to remove sludge formed in the neutralisation of an acid sugar solution obtained by the hydrolysis of wood[36]; and the history and development of machines for the sugar industry.[37, 38]

Process patents cover the purification of



[Photo: Pott, Cassels & Williamson

Fluid-driven centrifugal. Repeated and prolonged acceleration from rest of a high inertia load, such as a centrifugal basket, is an onerous duty for a squirrel-cage motor; it is heavy duty also for the switchgear. In contrast, a squirrel-cage motor, driving through a scoop-controlled fluid coupling, works under highly favourable conditions, since the motor is started once, under virtually no load, and then runs continuously while the hard work of accelerating the basket is carried out by the fluid coupling. For mechanical discharging of the contents of the centrifugal basket the scoop control is moved to a position to give a suitable torque for the operation and a safe speed range of 50 to 70 r.p.m. is maintained automatically by means of a plough speed controller

The centrifugal shown in the photograph incorporates fluid coupling, hand wheel control and mechanical discharger. For centrifugals which have a large number of complete cycles per hour, arduous braking as well as acceleration duties are encountered.

This problem of a quick acceleration and quick reduction of speed has been solved by employing a duplex fluid coupling which embodies two separate circuits, one for accelerating and the other for braking, also a rotating reservoir which contains the hydraulic medium. Fitted within this reservoir is a retractable sliding scoop by which oil is fed through a tubular cooler to one circuit or the other, as controlled by a diverter valve. The squirrel-cage driving motor can be started and run up to full speed against virtually no load by a direct-on switch. The motor can be left running. On opening the diverter valve to the accelerating circuit and moving the scoop tube into the oil reservoir, the motor accelerates the centrifugal to maximum speed. On moving the diverter valve so that the oil enters the braking circuit the centrifugal is reduced to about half speed in 15 sec. and then further reduced by mechanical braking. The main advantages can be summarised as simplicity and ease of operation.

sugar juices by carbonation in the presence of lime, followed by removal, washing and re-separation of the sludge centrifugally,[39] and the removal of impurities in the preparation of glutamic acid.[40] Other patents for auxiliary equipment working on sugar centrifugals include a friction clutch,[41] a time-operated water brake,[42] a time-operated speed control,[43] discharging controls,[44, 45] an electro-magnetic clutch[46] and an electrically-operated charging valve to prevent overloading.[47]

Brewing and fermentation

Various types of centrifuges are available for the treatment of beer at different stages in the brewing process. Hurlimann[48] discusses the brilliance obtained and degree of removal of bacteria, in relation to the speed of the centrifuge bowl. A further reference has been made to beer clarification,[49] a patent covers a method and machine for purifying beer[50] and, in a review of brewing technology, it is stated that the practice of removing trub from wort as carried out in Europe does not appear to be finding favour in America.[51] It is reported that centrifuging apple juice for cider production, so as to remove undesirable yeasts and yeast nutrients, helps to retain sweetness after fermentation[52] and in wine clarification considerable saving in filter-aid can be brought about by using centrifuges for removal of solids other than colloidal matter.[53] If the machine is used in conjunction with fining agents it is possible to obtain the solids in a sufficiently coarse form for their complete removal and a brilliant wine is produced.

A well-presented paper by Dawson[54] describes the production of baker's yeast and the part played by separators in its manufacture; by such means the yeast is concentrated from 50-100 g./l. to 600 g./l. of pressed yeast, followed by washing and reconcentration before filtration; an account of the preparation of food yeast on a pilot-plant scale follows similar lines.[55] The economic disposal of distillery slop is an important problem, and information regarding its treatment by centrifuging to recover the yeast for feeding stuffs or re-use has been given.[56, 57]

Vegetable oil, fats and soap

The application of centrifuges for processes in these industries continue to prove of value, but for the most part the published information relates to patents; among those covered are the continuous solvent extraction of oil seeds by multi-stage mixers and centrifuges,[58] degumming of soya-bean oil,[59] removing gums and waxy material by cooling to 20 to 50°F., mixing in a refining agent and then centrifuging,[60] a process for the removal of precipitated impurities formed by adding a refining agent to a crude vegetable oil containing up to 25% organic solvent,[61] soda ash refining and centrifuging the oil/soap mixture under a pressure of 10 to 50 p.s.i. and at a temperature of 70 to 110°F.,[62] a claim for the reduction of refining losses by mist mixing an oil and a solution containing caustic soda and sodium silicate followed by centrifugal removal of the soapstock,[63] and a continuous butter process involving neutralisation of sour cream followed by centrifuging in a special machine to a fat content of 80 to 85%.[64]

In an Indian vegetable oil refinery, it is reported[65] that the use of a De Laval soapstock separator has proved of considerable value for the recovery of neutral oil from soapstock obtained in the conventional gravity-settling batch process; some data are given which show that up to 50% of the neutral oil present in the soapstock can be recovered, thus reducing the refining factor from 2.5 to 1.6. In the post-refining of hydrogenated oils the results have been even more spectacular, as the conditions are such that the degree of emulsification and saponification are high; the refining factor for the normal gravity settling operation is over 6; data are presented showing that this factor is reduced to 1.5 to 2 by utilising the centrifuge. Another installation[66] utilises centrifuges for the dehydration of crude whale oil prior to splitting and again for glycerin and water removal from the fatty acids so produced.

Details of a new process for extracting oils and fats have now been released.[67, 68] This involves subjecting prepared fat-containing materials to high mechanical impulses transmitted by cold water, which break up the cells and release the fat; the solid residue is further washed with hot water, which removes any fat adhering to it and passes on for additional treatment. Both the cold and hot effluents are centrifuged in a Broadbent or a De Laval nozzle-type separator for the recovery of the fat, followed by a final purification in a standard disc-type machine. The process has been well tested for the treatment of bones, and its use for other fatty materials of vegetable, animal and marine origin is envisaged; considerable saving in capital and operating costs as well as improved quality and yields are features claimed for this new process.

In the production of soap, passing reference is made to the use of a nozzle-type machine for the removal of dirt from the raw material prior to saponification,[69] and the various types of machines suitable for the removal of salt from sweet-water in the production of glycerin are described.[70] A patent covers the use of a centrifuge for the separation of lye from neat soap which has been suitably conditioned by the addition of an electrolyte.[71]

Fish oil and meal

On this subject, a comprehensive paper reports the utilisation of protein concentrates as feedingstuffs prepared from the alkali digestion of herrings[72]; three types of products were examined, one of which was prepared by digesting the fish in weak alkali, centrifuging off the liberated oil, acidifying the aqueous liquor, and re-centrifuging to recover and wash the precipitated protein. Other brief references involving centrifugal treatment include the removal of oil and solids from whale glue water,[73] conventional methods for treating fish,[74] liver oil residues obtained from trawlers,[75] and the recovery of oil from the lean meat and liver of the whale on board a factory ship.[76] Patents have been lodged for a process for the production of oil and proteins from fish,[77] disintegrating and recovering oil from fish livers[78] and the separation with the addition of alcohol of emulsions produced in the alkali refining of fish oil.[79]

Fuel oil

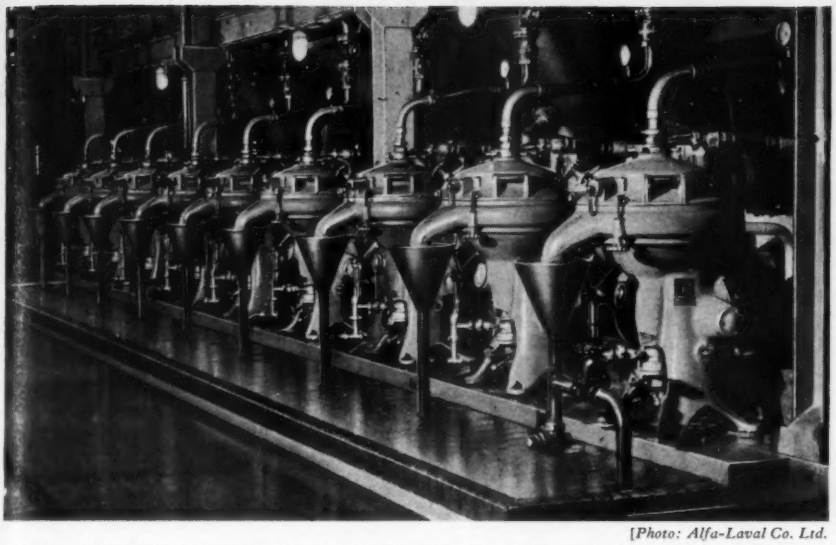
Centrifuging of heavy fuel oil for use in marine diesel engines has now become universal practice; a recent report,[80] summarises the performance of the pioneer vessel, M.V. *Auricular*, which has now completed over 5½ years' operation using various sources of bunker fuel of viscosities up to 3,500 seconds Redwood 1 at 100°F. The treatment of these heavier types of fuel oil consists of preheating to 180°F. and passing it through two standard types of De Laval centrifuges in series; one is arranged as a purifier which removes water and the coarser solid matter, and the other machine operates as a clarifier for removing the finer types of solids. The successful use of this type of fuel has resulted in considerable financial saving, due to the lower cost as against the normal diesel fuel, and without any sacrifice in engine performance. Undoubtedly, the use of centrifuges in this field has played a large part in bringing about this remarkable achievement, and it is confirmed by a number of references to some of the 500 installations of this type which have been, or are being, completed.[81–105]

The presence of sulphur in this type of fuel has received some attention and, although centrifuging does not appear to effect any considerable reduction due to the majority of the sulphur being in solution, opinions are divided as to the effect it has in relation to engine wear and corrosion.[80, 106, 107]

Other uses in petroleum processing

As the centrifuging of lubricating oil is quite standard practice, very little information is published; many of the instances outlined above for fuel oil treatment refer to machines being installed for lubricating oil purification, but no unusual features are reported. A paper dealing with rolling mill lubricants[108] suggests that, in the event of an emulsified oil being stabilised by iron soaps, it should first be centrifuged in a cold condition to remove the soaps (insoluble at low temperatures), and then hot to remove water.

On the process side, however, several items of interest have been reported. The advantages of two-stage centrifugal refin-



[*Photo: Alfa-Laval Co. Ltd.*

Battery of nozzle separators for the continuous separation and concentration of starch. They are fitted with an independent device for washing out soluble and insoluble impurities from the starch concentrate.

ing of lubricating oil are described in a recent paper.[109] The process details, such as acid strength and quantity, contact time, temperature, etc., for various grades of oil have been thoroughly investigated, as these factors play an important part in obtaining the maximum yield of high-quality oil in the centrifuging operations. Comparisons are drawn between the consumption of after-treatment chemicals for single- and double-stage refining for a finished oil of constant quality, which illustrates the value of the additional stage. The problem of acid sludge disposal is also dealt with and reference is made to the recovery of acid after hydrolysis using a centrifuge.

A new process for the production of shale oil utilises a mist separator and centrifuge for the recovery of dry oil from the retort gases,[110] and the centrifugal removal of acid sludge from shale distillate in the production of detergents is reported.[111] In an abstract dealing with a new dewaxing process,[112] it is suggested that the agent will readily facilitate the precipitation of the wax in a form suitable for centrifugal separation and give results equal to those obtained by filtration; a patent[113] refers to the manufacture of paraffin wax using sawdust and centrifugal separation under controlled temperature conditions. Another patent[114] for the centrifugal separation of bleaching earth from oil, using an immiscible liquid to carry away the earth, has considerable potential application in the refining of petroleum products.

Chemical processing

The many and diverse process conditions in the chemical industry provide many applications for centrifuges, and the information published gives an indication of how the machines may be applied to other problems. The manufacture of lactose[115] utilises disc-type and perforated basket machines respectively for skimming off cream and separating and washing the crude and refined product obtained from the whey. In the pilot-plant production of protein from groundnut meal,[116] investigations have been made of the suitability of various combinations of centrifuges for dewatering solids, clarification and recovery of the precipitated protein; these include a Bird continuous horizontal machine, an International solid basket-type and a De Laval *Multimatic* machine. For the continuous removal of impurities from bentonite clay a horizontal solid bowl and a high-speed automatic machine operate in series[117]; a high-speed purifier removes water from a turpentine solution of pine gum and a basket machine is employed for the recovery and washing of crystals of maleo-pimaric acid produced at a later stage.[118]

Other uses of basket machines for crystal recovery have been reported in the following processes: *p*-xylene from a mixture of xylenes[119]; silver nitrate production[120]; copperas from dilute sulphuric acid recovered from pickling liquors[121, 122]; hydroquinone production[123]; ammonium nitrate manufacture[124]; naphthalene as by-product from oil gas generators[125]; inositol production[126] and in a new process for the refining of common salt.[127]

Centrifugal dewatering operations have proved of value in the manufacture of *Napalm*[128] and cellulose acetate,[129] for the treating of lime mud obtained in the recausticising process in paper making[130] and in the disposal of tannery wastes.[131]

Antibiotics often require counter-current liquid liquid extraction for their production, and specialised machines such as the Podbielniak or the single- or multi-stage disc-type machines are employed; references to the production of penicillin in this manner have been outlined.[18, 132, 133] In the preparation of more specialised pharmaceutical products the use of centrifuges have been described for the fractionation and recovery of dextran,[134] recovery of precipitated riboflavin[135] and clarifying extracts in the production of insulin.[136] The centrifugal concentration of sludge in sisal juice for the recovery of hecogenin (for cortisone synthesis) has been suggested.[137]

Starch

Centrifuges play an important part in the production of this material and the practice has been reviewed with special reference to maize starch[138]; continuously operating De Laval machines are employed for simultaneously separating off gluten, washing the starch to remove traces of gluten and concentrating before filtering or basket centrifuging; the centrifugal concentration of gluten is also mentioned as well as several patented processes for gluten/starch separation using centrifuges. Other references include the dewatering of corn starch in 72-in. Baker-Perkins machines which are over-charged initially to wash away protein,[139, 140] and a solid bowl machine for removing fruit water and cellulose from tapioca starch followed by dewatering in perforated basket machines.[141]

Miscellaneous

For the treatment of fruit juice, centrifuges are employed for removing ice crystals in a new concentration process using refrigeration,[142] recovering essential oils from citrus fruits[143, 144] and clarifying apple juice.[145]

Removal of lignin in paper pulp manufacture by a new solvent process utilises centrifuges for separating the pulp from the solvent.[146] The operation of the Bird continuous solid-bowl machine for classifying and settling products in the paint industry has been described.[147] Latex centrifuges of improved design have resulted in longer running periods and better yields of high-quality concentrates.[148] The recovery and processing of guanine by centrifuging is a very desirable feature in pearl essence manufacture.[149] The use of a special type of De Laval clarifier for removing water and solid matter from white spirit in the dry-cleaning industry has been reported.[150]

Patented processes involving centrifugal separation have been lodged for the production of malt extract,[151] sludge separation,[152] red muds[153] and gas mixtures.[154]

A further patent covers the combined operation of a filter and centrifuge[155] and details of a centrifugal for washing and drying ampoules have been disclosed.[156]

REFERENCES

[1] M. M. Haruni and J. A. Storrow, *Ind. & Eng. Chem.*, 1952, **44**, (11), 2751.

[2] C. M. Ambler, *Chem. Eng. Progress*, 1952, (3), 150.

[3]F. Rumford, Chemical Engineering Operations, London, 1951, 254.
[4]J. O. Maloney, *Ind. & Eng. Chem.*, 1952, **44**, (1), 39.
[5]*Food Manufacture*, 1952, (6), 251.
[6]B.S. 767: 1951 (Hydroextractors and centrifugal machines), British Standards Institution.
[7]J. C. Smith, *Chem. Eng.*, 1952, **59**, (4), 140.
[8]J. D. Leonard, *Ibid.*, 1951, **58**, (9), 150.
[9]*International Chemical Engineering*, 1951, **32**, (9), 440.
[10]*Analytical Chem.*, 1952, **24**, (7), 25A.
[11]*Chem. Eng.*, 1952, **59**, (9), 178.
[12]*Paint Manufacture*, 1951, **21**, (5), 169.
[13]C. M. Gough and E. H. Green, *J. of Applied Chemistry*, 1952, (4), 198.
[14]H. J. Kamack, *Analytical Chem.*, 1951, **23**, (6), 844.
[15]E. Freyer and V. Shelburne, *J. American Oil Chemists*, 1951, **28**, (9), 393.
[16]R. C. Jarnagin, *et al.*, *Analytical Chem.*, 1952, **24**, (7), 1115.
[17]J. S. Wiberley, *et al.*, *Ibid.*, 1951, **23**, (10), 1369.
[18]H. Eisenlohr, *Ind. Chem.*, 1951, (6), 271.
[19]*Chem. Eng.*, 1951, **58**, (11), 186.
[20]*Ibid.*, 1952, **59**, (7), 230.
[21]*Ibid.*
[22]Brit. Pat. 651,681.
[23]Brit. Pat. 675,417.
[24]Brit. Pat. 657,290.
[25]F. Broadbent, *Internat. Sugar J.*, 1952, **54**, (5), 128.
[26]E. Ruegg, *Ibid.*, 1952, **54**, (8), 212.
[27]R. J. Martinez, *Ibid.*, 1952, **54**, (6), 163.
[28]Brit. Pat. 653,126.
[29]L. A. Tromp, *Internat. Sugar J.*, 1952, **54**, (6), 159.
[30]W. R. Crawford, *Proc. Queensland Soc. of Sugar Cane Technologists*, 18th Conference, 1951, 121.
[31]F. E. Gay, *Internat. Sugar J.*, 1952, **54**, (7), 190.
[32]C. G. M. Perk, *Ibid.*, 1952, **54**, (7), 188.
[33]F. M. Chapman, *Ibid.*, 1952, **54**, (3), 69.
[34]K. Douwes Dekker and W. Elbers, *Ibid.*, 1951, **53**, (8), 222.
[35]C. C. Savoie, Proceedings of 7th Congress of International Society of Sugar Cane Technologists, 584.
[36]N. Gilbert, *et al.*, *Ind. & Eng. Chem.*, 1952, **44**, (7), 1712.
[37]O. Lyle, *Chem. & Ind.*, 1951, (3), 164.
[38]N. Deer, 'The History of Sugar,' Vol. II, London, 1950, 573.
[39]Brit. Pat. 666,781.
[40]U.S. Pat. 2,487,785.
[41]Brit. Pat. 666,018.
[42]U.S. Pat. 2,548,299.
[43]U.S. Pat. 2,551,838.
[44]U.S. Pat. 2,485,465.
[45]U.S. Pat. 2,517,409.
[46]U.S. Pat. 2,544,367.
[47]Brit. Pat. 653,125.
[48]H. Hurlimann, *J. Inst. Brewing*, 1951, **57**, (1), 21.
[49]H. Munder, *Brauwelt*, 1950, **40**, 845.
[50]Brit. Pat. 663,141.
[51]L. Wallerstein, *et al.*, *Ind. & Eng. Chem.*, 1952, **44**, (11), 2768.
[52]*Bottler and Packer*, 1951, (12), 118.
[53]*Ibid.*, 1952, (3), 103.
[54]E. R. Dawson, *Chem. & Ind.*, 1952, **33**, (8), 793.
[55]D. G. Padalkar, *India Sugar*, 1950, **14**, (8), 158.
[56]E. L. Symes, as ref. 35, 569.
[57]U.S. Pat. 2,572,447.
[58]U.S. Pat. 2,505,139.
[59]U.S. Pat. 2,508,919.
[60]U.S. Pat. 2,564,407.
[61]U.S. Pat. 2,576,957 8.
[62]U.S. Pat. 2,607,788.
[63]U.S. Pat. 2,512,245.
[64]U.S. Pat. 2,526,292.
[65]G. V. Ramaswami, *J. Sci. & Ind. Res.*, 1951, **10A**, (7), 292.
[66]*Chem. Eng.*, 1952, **59**, (10), 328.
[67]*Food*, 1952, (12), 452.
[68]*Engineer*, 1952, (11), 627.
[69]E. M. James, *J. Amer. Oil Chem.*, 1952, **29**, (11), 485.
[70]W. A. Peterson, *Ibid.*, 1952, **29**, (11), 511.
[71]Brit. Pat. 662,648 and U.S. Pat. 2,572,102.
[72]K. J. Carpenter, *et al.*, *J. Science of Food & Agric.*, 1952, **3**, (6), 278.
[73]D. J. S. Gray, *et al.*, *Ibid.*, 1951, **2**, (10), 450.
[74]G. T. Bray, *Paint Manufacture*, 1951, **21**, (12), 452.
[75]J. A. Lovern, *Chem. & Ind.*, 1952, **2**, (1), 38.
[76]*International Chemical Engineering*, 1952, **33**, (1), 28.
[77]Brit. Pat. 664,827.
[78]U.S. Pat. 2,507,614.
[79]Italian Pat. 461,372.
[80]*Motor Ship*, 1952, **33**, (5), 57.
[81–105]*Ibid.*, 1952, **32**, (1), 429; (2), 444; 476; (3), 499; **33**, (4), 12; 33; (5), 49; 72; (6), 92; 104; (7), 130; 140; 146; (8), 182; (9), 227; 230; (10), 256; 282; 289; (11), 300; 302; 327; (12), 337; 344; 368.
[106]C. D. Brewer, *Engineer*, 1952, **193**, 275.
[107]*Gas, Oil & Power*, 1952, **47**, 75.
[108]S. F. Chisholm, *Iron & Coal Trades Rev.*, 1952, (6), 1247.
[109]F. Sager and F. Palmqvist, *Petroleum Refiner*, 1952, **37**, (6), 139.
[110]*Chem. Eng.*, 1951, **58**, (8), 202.
[111]S. F. Birch, *J. Inst. of Petroleum*, 1952, **38**, (2), 69.
[112]H. Poell, *Petroleum*, 1951, (10), 272.
[113]U.S. Pat. 2,568,946.
[114]Brit. Pat. 659,393.
[115]M. L. Kastens and F. A. Baldauski, *Ind. & Eng. Chem.*, 1952, **44**, (6), 1257.
[116]J. Pominski, *et al.*, *Ibid.*, 1952, **44**, (4), 925.
[117]*Chem. Eng.*, 1952, **59**, (3), 226.
[118]*Ibid.*, 1952, **59**, (2), 199.
[119]*Ibid.*, 1952, **59**, (4), 219.
[120]*Ibid.*, 1952, **59**, (10), 217.
[121]*Indus. Chem.*, 1952, (3), 125.
[122]*Ind. & Eng. Chem.*, 1952, **44**, (3), 512.
[123]*Ibid.*, 1952, **44**, (8), 1731.
[124]*Ibid.*, 1952, **44**, (8), 1912.
[125]*Ibid.*, 1952, **44**, (5), 936.
[126]*Chem. Eng.*, 1951, **58**, (8), 200.
[127]R. B. Richards, *Ibid.*, 1952, **59**, (3), 140.
[128]*Ibid.*, 1951, **58**, (11), 162.
[129]*Ibid.*, 1951, **58**, (8), 127.
[130]*Ibid.*, 1952, **59**, (3), 206.
[131]*Ind. & Eng. Chem.*, 1952, **44**, (3), 520.
[132]*Chem. Eng.*, 1951, **58**, (4), 174.
[133]*Ibid.*, 1952, **59**, (6), 189.
[134]*Ibid.*, 1952, **59**, (9), 216.
[135]Jap. Pat. 175,839.
[136]Brit. Pat. 671,750.
[137]P. C. Spensley, *Chem. & Ind.*, 1952, **19**, (5), 426.
[138]J. A. Radley, *Food Manufacture*, 1951, (11), 429; (12), 488; 1952, (1), 20. (3 parts).
[139]*Ind. & Eng. Chem.*, 1952, **44**, (4), 13A.
[140]*Chem. Eng.*, 1952, **59**, (3), 248.
[141]*Ind. & Eng. Chem.*, 1952, **44**, (4), 17A.
[142]*Bottler and Packer*, 1952, (1), 77.
[143]*Food*, 1951, (9), 336.
[144]*Ibid.*, 1951, (8), 317.
[145]*Bottler & Packer*, 1952, (7), 71.
[146]*Chem. Eng.*, 1951, **58**, (6), 202.
[147]*Paint Manufacture*, 1952, **22**, (9), 336.
[148]E. A. Murphy, *Ind. & Eng. Chem.*, 1952, **44**, (4), 756.
[149]A. J. Krajkeman, *Paint Manufacture*, 1952, **22**, (10), 371.
[150]E. Albinson, *Power Laundry*, 1952, (4), 791.
[151]Brit. Pat. 649,204.
[152]U.S. Pat. 2,532,792.
[153]U.S. Pat. 2,537,629.
[154]U.S. Pat. 2,536,423.
[155]Brit. Pat. 670,260.
[156]*Chem. Eng.*, 1952, **59**, (2), 212.

Recent publications

Chemical pumps. A leaflet on their A-N chemical pump, a unit which is already giving efficient service in plants for I.C.I., Shell, Anglo-Iranian, Esso, Petrocarbon, Monsanto, Associated Ethyl, Distillers Co., etc., has been issued by Sigmund Pumps Ltd. Design specifications and performance data for the A-N range are given in the leaflet and the feature described as the unit interchangeability principle will appeal in particular to those who use large numbers of pumps for different applications. In the A-N pump design the impellers and volute can be changed to meet different capacity/head conditions or material specifications whilst using the same bearing and support frame. In this way spares stocks can be carried at a new low level and considerable savings can be achieved.

Glass plant. A new illustrated leaflet dealing with industrial plant in glass has been produced by Quickfit & Quartz Ltd. The leaflet states that industry has proved glass to be a thoroughly robust material, capable of standing up to most rigorous manufacturing conditions. This has resulted in a rapid and continuous widening of the applications of *Quickfit* industrial scale glassware.

Ammonium dichromate precautions. Instructions for the safe handling and use of ammonium dichromate, which is widely used in the chemical and allied industries, are contained in Chemical Safety Data Sheet SD-45, issued by the Manufacturing Chemists' Association, Inc., U.S.A. Important physical and chemical properties of ammonium dichromate are given for the information of people handling and using it. It will ignite if exposed to flames or sparks. At elevated temperatures it decomposes and may react explosively with certain organic substances. Essential information about hazards to be anticipated in shipping, storage, unloading and emptying containers is given in detail. A section on health hazards and their control outlines first-aid measures, personal protective equipment and precautions to be observed by workers who come in contact with the chemical. Unless employees are familiar with its properties, local irritation of mucous membranes and skin are possible, and harmful effects may be produced if swallowed or inhaled. The high colouring power of ammonium dichromate, red to orange, is a useful indicator in washing exposed skin or clothing. The absence of colour indicates that the chemical has been completely removed.

Future articles: Reviews of 'Pumping' and 'Evaporation'; Demineralisation of Salt Waters; Production and Uses of Germanium; Disposal of Contaminated Air from Radiochemical Laboratories; Utilisation of Solar Energy

Carbon Dioxide from Fuel Oil

CARBON dioxide is produced commercially by three principal processes: (1) as a by-product from fermentation processes; (2) by the acid/carbonate reaction; and (3) by absorption and recovery from CO_2-bearing flue gases.

Until recently small compact plants could only be designed and manufactured on the basis of the acid/carbonate reaction, but Kestner Evaporator & Engineering Co. Ltd. of London, have now produced a range of small, compact, highly-efficient plants for the manufacture of liquid carbon dioxide by the fuel oil process.

This is known as the *Kestnamine* process and plants currently being manufactured have outputs of 200 or 100 lb. hr.

The process is briefly as follows: a good-quality mineral fuel oil (preferably desulphurised) is burned with the minimum excess air in the furnace of a lye heater by means of a special proportioning oil burner capable of producing a flue gas approaching the theoretical CO_2 concentration, *viz.* 15% v/v. It is of prime importance that this CO_2 concentration be maintained as high as possible consistent with complete combustion. Incomplete combustion must also be avoided with its attendant formation of unburned carbon and/or carbon monoxide, the latter usually being detected by an unpleasant smell in the water leaving the raw gas cooler and the CO_2 recorder seal pot below the instrument panel.

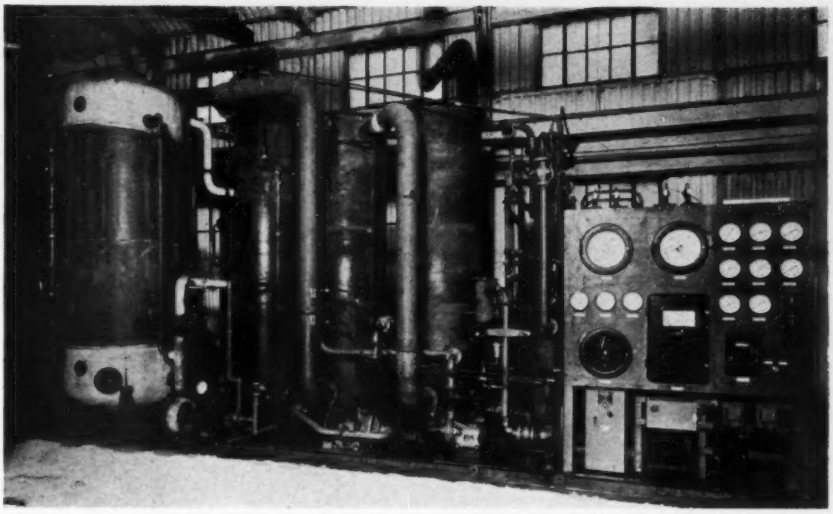
Fuel oil from a main storage tank is supplied to a small holding-tank supplied with the plant which is provided with a level gauge glass. A motor-driven fuel oil pump is provided along with an electric oil heater for use with heavy fuel oils having a viscosity of the order of 200 sec. Redwood 1 at 100°F.

Combustion air for the burner is provided under pressure by means of the motor-driven rotary positive displacement type air-blower, which also serves to drive the combustion gases through the raw-gas side of the plant.

The production of high-CO_2 combustion gases is associated with very high flame temperature within the furnace and this, in turn, enables a high proportion of the heat of combustion to be transmitted to the lye circulated through the heating coil in the upper section of the lye heater.

Partially-cooled flue gases from the top of the furnace then pass to a direct-contact water spray cooler and the quantity of cooling water supplied to this should be adjusted to give an exit flue gas temperature of 45°C.

The cooled flue gases from the cooler pass to the SO_2 scrubber, in which acidic sulphur gases are absorbed by means of a 10% solution of sodium carbonate in water, which is circulated by means of a pump from the base of the SO_2 scrubber to the three spray nozzles of that scrubber.



Side view of complete *Kestnamine* CO_2 plant excluding furnace and showing (*left to right*) stripper, SO_2 scrubber, two absorption towers and main control panel.

The cooled, scrubbed flue gases then pass through two absorption towers, where they meet the aqueous amine absorbent lye. This lye absorbs most of the CO_2 from the flue gas, which is then discharged to atmosphere from the branch at the top of the second absorption tower. The rejected gases from the raw-gas circuit consist mainly of nitrogen with a little CO_2 saturated with water vapour. These gases are quite harmless, but if the building housing the CO_2 plant is small and totally enclosed, they should be led outside the building and discharged to atmosphere.

Any additional duct-work for this purpose should not impose any appreciable additional resistance on the flue-gas system.

Cool, stripped lye enters the top of the second absorption tower and, after partial enrichment, is pumped from the base of this vessel to the top of the first absorption tower. Enrichment of the lye is complete in this tower and the rich lye from the base of this unit is pumped to a heat exchanger. The temperature of both gas and liquid in the absorption section should be maintained at about 45°C.

In the heat exchanger the cool, rich lye receives heat from hot, stripped lye leaving a stripper, and passes to the top of the stripper at a temperature of about 120°C. This stripper is a ring-packed tower generally similar to the absorption towers and, as the lye passes down this section, it meets a current of steam which strips from the rich lye the CO_2 absorbed in the absorption section. This stripped steam is generated by the circulation of stripped lye from the base of the stripper through the heating coil in the top section of the lye heater. It is of prime importance that the full quantity of lye be circulated through the heater coil during operation and also both before the burner is lit and for an adequate period after the plant has been shut down.

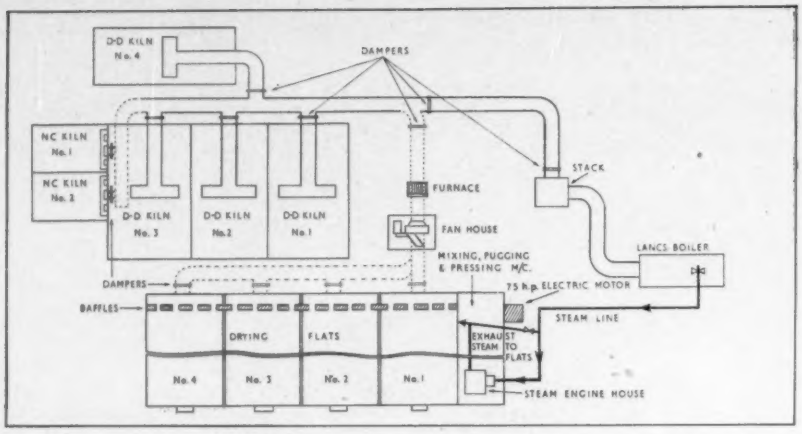
Stripped, hot lye leaves the bottom of the strippers and passes through a level control chamber. If the level in the stripper and hence in the chamber should fall, owing, for example, to cessation of flow of lye to the stripper from the heat exchanger or one of the pumps, the float valve in the level control tank would open, allowing lye to flow from an annular buffer storage vessel, thus safeguarding the lye heating circuit. This will only be effective so long as there is a head of lye in the buffer storage vessel and does not relieve the operator of the necessity to reduce or stop the transfer of lye from the stripper through the heat exchanger and cooler to the absorption section by adjusting the valve connected to the lye cooler.

The stripping section is operated under a positive pressure of (normally) 40 p.s.i.g. This serves to force the hot, stripped lye through the heat exchanger and cooler to the top of the second absorber tower without the necessity of a separate pump.

From the level control tank the hot, stripped lye passes through the heat exchanger, where it gives up most of its heat to the incoming rich lye, and then through the lye cooler where it is cooled to 45°C. by interchange with cooling water. This cooled, stripped lye is then returned to the top of the second absorber for a fresh absorption and stripping cycle.

The CO_2 stripped from the rich lye in the stripper, accompanied by a proportion of stripping steam, passes to the CO_2 cooler where the steam is condensed out and the CO_2 cooled to as low a temperature as can be achieved by the cooling water available. The condensate is then separated from the gas and returned to the base of

(*Concluded overleaf*)



Original and modified (– – – –) layout.

Waste Heat from Brick Kilns helps Fuel Economy Scheme

BY carrying out certain plant modifications and by utilising waste heat from the kilns for drying purposes, the Novo Brick & Tile Co. Ltd., of Scotswood, Newcastle, reduced coal consumption by 20 tons a week (net) and by doing so saved £3,000 a year.

The plant includes six kilns, four of which are of the central down-draught type, fired at three points at each end and connected by the centre outlet flue to a common flue leading to the main chimney. The other two are ordinary kilns fired at three points at the front end, draught being maintained by the sectionalised small chimney on each kiln.

The kilns are usually set with a mixed load of hollow partition blocks and pipes; the average coal consumption per kiln is between 12 to 14 tons over a firing period of four to five days; the highest temperature attained is 950 to 1,000°C.

A hand-fired Lancashire boiler (30 ft. × 8 ft. 6 in.) equipped with steam jet forced draught supplied steam at 80 to 100 p.s.i. to a rather old single cylinder reciprocating engine that provided power for the clay mixing, pugging and extruding machinery.

When the engine was in operation, exhaust steam was blown beneath the drying flats which have a total area of 11,600 sq. ft., the floor itself consisting of large cast steel plates. At other times, steam was supplied direct from the boiler.

After a survey of the works it was recommended that the steam engine should be replaced by a 60 to 75 h.p. electric motor and that waste heat from the kilns should be used for heating the drying flats.

Before the scheme for the utilisation of waste heat for drying was prepared, tests were made to ascertain the temperature of the flue gases at the base of the stack and along the flue between the kilns and the stack. Draught readings were taken at the base of the stack, at the dampers in the flues and at the firing points of each kiln. Surface temperatures were also taken on the floor of the drying flats.

The first section of the total scheme to be carried out was the conversion to electric drive of the plant machinery by the installation of a 75 h.p. electric motor. The coal consumption at the boiler plant was reduced from 22 tons a week to 12 to 15 tons a week to provide steam for the drying flats.

Next, a new cross flue was constructed, incorporating a 3 ft. diameter impeller type fan, belt driven by a 25 h.p. electric motor, connecting the four down-draught kilns with the drying flats. During the normal firing and cooling periods hot gases are drawn from the four kilns by the fan and blown through four distribution flues beneath the flats. The gases travel the full length of each flat to the exit through a small stack at the end of each section and their flow beneath the flats is spread by baffles. The four kilns did not provide enough waste heat for drying to maintain the six kilns on the normal cycle of operations and it was necessary to augment the heat of the waste gases by burning one and a half to two tons of coal a week in a small furnace built between the kilns and the fan above the new cross flue. The boiler plant was closed down and the boiler attendant became available for other work.

The scheme was completed when the waste gases from the other two kilns were connected to the fan flue system since, with this additional heat, it was possible to operate without using the furnace to augment the heating of the drying flats.

The actual fuel saved is 22 tons a week at the boiler plant, offset—from a national point of view—by the consumption of about two tons a week for the equivalent fuel requirements at the power station to drive the two electric motors.

Based on a 50-week year at 20 tons a week and a cost of about £3 per ton of coal, the financial saving is £3,000 per annum.

The other direct saving is wages for one man during summer and two men during winter at an average of £10 per week (£500 per annum); it is contended that this saving will almost cover the cost of increased electric power. A large proportion of the building work was carried out by the works staff and it is estimated that the total cost of the scheme involved a capital expenditure of £1,500.

From *Fuel Efficiency News*, 1952, **3**, (1).

CO_2 from Fuel Oil

(*Concluded from previous page*)

the second absorption tower (in order to maintain the working concentration of the lye) by means of a condensate trap. A flow glass is provided in the line after the trap, giving visible indication that the trap is functioning correctly, and a three-way cock is provided to permit discharge of condensate to drain if it is found at any time that the lye is being progressively diluted by, for example, the absorption of water vapour from the flue gases.

The CO_2 from the separator after the CO_2 cooler, passes through both sections of the rich-gas purifier, which contains a solution of alkaline permanganate. The object of this item is to remove taste- and smell-producing traces from the gas and a system of pipework and valves is provided to facilitate replacement of the solution during the operation.

The purified CO_2 then passes to the suction of the compressor which compresses the gas to the usual bottle-filling pressure of up to 1,800 p.s.i.g. The compressed CO_2, on leaving the compressor, passes first to a separator, where moisture and any glycerin carried over from the compressor is collected, and then to high-pressure purifiers and driers which contain activated carbon and activated alumina respectively for the final purification of the gas. From these vessels the gas then passes to the four-point cylinder charging header to which the CO_2 cylinders are connected. During filling, the cylinders are supported on spring balances which enable the operator to determine when each cylinder has been charged with the correct weight of CO_2.

Silver-plated aluminium

Development of a new process for silver-plating aluminium has been described by engineers of the General Electric Co., Philadelphia. The process is used to eliminate joint failure which is sometimes caused by a high-resistance aluminium oxide film. It is currently being applied to cables and connectors. Studies on its use for other items are in progress.

Ion Exchange and Fine Chemicals

A MEETING of the Fine Chemicals Group of the Society of Chemical Industry was held on December 12, 1952, at King's College, London, when Mr. E. L. Streatfield, B.Sc., F.R.I.C., M.I.Chem.E., of Filtrators Ltd., delivered a lecture entitled ' Ion Exchange and its Applications in the Fine Chemical Industry.'

After introduction by the chairman, Dr. Wm. Mitchell, Mr. Streatfield said the phenomenon of ion exchange has assumed such importance in recent years in the fields of agriculture, biology, medicine and chemistry, that it is now regarded as a unit operation in common with such classic operations as distillation, adsorption and filtration. Ion exchange was first recognised by Thompson and Way in 1850, but it was not until the beginning of the 20th century that ion exchange became a unit operation on an industrial scale, when Gans employed both natural and synthetic aluminium silicates for softening waters and also for treating sugar solutions. The siliceous ion exchangers had certain limitations, principally that of instability towards acids and alkalis and, therefore, an extremely important advance was marked by the discovery of Adams and Holmes in 1935 that phenol and aromatic amines, when condensed with formaldehyde, would give insoluble synthetic resins with acidic and basic properties respectively. Since that time a number of high-capacity, durable, ' tailor-made ' ion exchange resins have made their appearance.

Several theories have been put forward to explain the mechanism of ion exchange, namely (1) the crystal lattice theory of exchange of ions in crystals; (2) the modified Helmholtz double-layer theory; and (3) the Donnan membrane theory. Essentially, all ion exchange theories are similar in that the exchange of ions must satisfy the laws of electro-neutrality.

Ion exchange resins are essentially polymeric electrolytes containing highly cross-linked non-diffusible polar groups whose charges are balanced by diffusible cations or anions. In the case of the cation exchange resins, the exchange groups are generally nuclear sulphonic, SO_3H, methylene sulphonic, $CH_2.SO_3H$, carboxylic, COOH, and phenolic, –OH, and in the case of the anion exchange resins substituted amino groups, $-NH_3.OH$ or $\equiv N.OH$.

Preparation of resins

Exchange resins have been prepared by polymerisation-condensation and vinyl polymerisation. In polymerisation-condensation, the ionic groups are built into the resin structure during polymerisation, *e.g.* the reaction between phenol and formaldehyde or between *m*-phenylenediamine and formaldehyde. In vinyl polymerisation, a polymer unit is first formed and the ionic groups are subsequently introduced into the hard polymer structure, *e.g.* the polymerisation of styrene to polystyrene which is cross-linked with divinylbenzene, the copolymer being then sulphonated to give a nuclear sulphonic acid-type cation exchanger. In the preparation of ion exchange resins, the porosity of the resin may be varied according to the degree of cross-linking, which allows of considerable selectivity in use by either ' blocking-out ' or ' absorbing ' large organic molecules as required.

The applications of ion exchange in the fine chemical industry may be considered broadly under four headings:

(*a*) **De-ionisation or purification processes.** All ions may be removed from solutions by using both an anion and cation exchanger either in series or as a mixed bed. Examples of application are in the production of water of high purity and in the purification of formaldehyde, glycerin and proteins. The mixed-bed technique is of particular advantage for the de-ionisation of acid-sensitive solutions such as certain biological fluids and sugar solutions.

(*b*) **Processes involving exchange of ionic constituents.** An ion in a solution may be exchanged with another ion in an ion exchanger without change in concentration. Examples are the exchange of sodium ions in a cation exchanger for the calcium and magnesium ions in water (water softening), the conversion of potassium penicillin salts into the sodium salt (cation exchange) and the conversion of streptomycin sulphate into the chloride (anion exchange).

(*c*) **Separation processes.** The separation of electrolytes in a solution may be achieved with either type of exchanger if the two ionic species are of opposite charge, or the two ionic species, if of like charge, may be separated with an exchanger which will adsorb only one of the species (the ' ionic sieve ' effect) or both may be adsorbed by the same exchanger and a chromatographic separation achieved. Examples are the separation of amino-acids from protein hydrolysate, the isolation of cinchona alkaloids, and separation of high molecular weight polyelectrolytes from their low molecular weight fragments.

(*d*) **Recovery processes.** The direct adsorption of large organic molecules by highly expanded porous ion exchangers to separate them from impurities in solution, is illustrated by the purification of streptomycin and constituents of the vitamin B complex.

Ion exchange resin adsorbents have also been studied as chemical therapeutic agents with spectacular results, as, for example, in peptic ulcer therapy, in œdema therapy and as bacterial adsorbents.

Discussion

In opening the discussion, Dr. Mitchell said that a disadvantage of ion exchange for the isolation of, for instance, an alkaloid, was the considerable dilution incurred on eluation. Mr. Stroud said that this could be minimised by slurry eluation. Dr. H. J. Barber pointed out that displacement of an alkaloid from a sulphonic acid resin could be an uneconomic process. Dr. M. W. Phillips pointed out the dearth of information on ion exchange processes actually in operation in Britain, while Mr. Miall thought that the cost of regeneration had limited their industrial use. He pointed out the need for a wider range of resins. Mr. Stroud said that in his experience the practical life of a resin was considerably shortened by the loss of fines, which Mr. Streatfield said was possibly due to the repeated swelling and shrinkage of the resin while in use, causing break-up of the granules.

Mr. Eastman asked if the removal of pyrogens from water in an ion exchange column threw any light on their nature, such as by their subsequent eluation, as suggested by Dr. Phillips, but Mr. Streatfield was not aware of any experiments on these lines. In reply to Mr. Hughson, who instanced the ready growth of slimes in de-ionised water, Mr. Streatfield said that this could be prevented by chlorination prior to the cation exchange stage.

Chemical packaging problem solved

A suggestion which solved the problem of venting excess air from bags in the process of packaging aluminum sulphate was recently adopted by American Cyanamid Co., U.S.A. The firm had long been plagued with this problem when packaging aluminum sulphate in heavy export bags which do not readily permit air to escape. The simple yet ingenious suggestion was merely to attach a piece of pipe just above the spout that pours the aluminum sulphate into the bags. Acting as an escape vent for the air, this device made possible a tighter, stronger package with less tendency to tear or burst. The vent, which is highly successful for granular materials sufficiently heavy to drop to the bottom of the bag, is not suitable for powders.

Tungsten plays a very important part in the industrial and domestic fields as a pure metal and as an alloying element. Although separated from cassiterite over 100 years ago, tungsten remained one of the rare metals until its importance in the lamp industry was realised as a result of much research work. Developments in the use of tungsten for lamp filaments commenced about 1904 and it has been used exclusively since. During this time its value has greatly increased, particularly in the production of many ferrous alloys, for which it has become indispensable. In an article in *Alloy Metals Review*, published by High Speed Steel Alloys Ltd., the methods of preparation, properties and applications are briefly reviewed.

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Hydrogen from sulphur hydrocarbons

Sulphur-containing hydrocarbons are passed over a nickel catalyst at a temperature greater than that required to obtain the same percentage of hydrogen from a similar sulphur-free hydrocarbon, and under similar reaction conditions. The sulphur content exceeds 0.5% by weight and the temperature increase is from 75 to 125°C. Catalysts used include nickel-magnesia, nickel-magnesia-zirconium silicate, nickel-alumina-magnesia, nickel-zirconium silicate, nickel-alumina, nickel-diaspore, nickel-pumice and nickel-titanium oxide, the nickel being 10% or more of the catalyst.—640,368, *Hercules Powder Co.*

Recovering chlorobenzene

Chlorobenzene is recovered by continuously hydrolysing *p*-chlorobenzenesulphonic acid by boiling a mixture comprising *p*-chlorobenzenesulphonic acid, sulphuric acid and water at a temperature below 240°C. and continuously removing vapours of water and chlorobenzene distilling from the boiling mixture. The vapours are condensed and *p*-chlorobenzenesulphonic acid is added to the boiling mixture together with an alkali metal compound capable of combining with sulphuric acid to form alkali metal acid sulphate. The amount of alkali metal compound added is insufficient to neutralise all the sulphuric acid in the boiling mixture, and the water is added in amount sufficient to maintain the boiling point of the mixture below 240°C. The amount of alkali metal compound is such that an aqueous inorganic layer forms below the mixture, the said inorganic layer comprising alkali metal acid sulphate, sulphuric acid and water. This layer is withdrawn at a rate substantially equal to that at which it is formed.

The *p*-chlorobenzenesulphonic acid may be the crude product formed as a by-product during the manufacture of 2, 2-bis-(*p*-chlorophenyl)-1,1,1-trichloroethane. The alkali metal compound is preferably a sodium compound, *e.g.* sodium hydroxide, and is added in such amount that the inorganic layer formed contains from 68 to 72% of sodium sulphate, 23 to 27% of sulphuric acid and from 4 to 6% of water. Other alkali metal compounds specified are sodium chloride and sodium sulphate.—641,041, *United States Rubber Co.*

Extracting tin ores

Tin is extracted from tin ores, wastes, stannic oxide, etc., by reducing the ore, etc., to convert the tin into a form capable of reacting with an alkali metal hydroxide solution, and thereupon treating with this solution at a temperature of 75°C. to the boiling point. Sodium, potassium or lithium stannate will thus be formed without simultaneously dissolving substantial amounts of impurities.

Reduction of the ore may be effected with carbon, coal, coke, lamp-black, carbon monoxide, natural gas, hydrogen, etc., at 760 to 1,090°C., avoiding appreciable fusion. High-grade ores containing 35 to 40% tin may be first mixed with inert material such as the spent residues of the later leaching operation. If excessive sulphur is present, this may be partially or wholly removed by a previous roast. The reduced ore may be cooled in a non-oxidising atmosphere. One mol. oxidising agent, *e.g.* an alkali metal nitrate, nitrite, peroxide, hypochlorite, hydrogen peroxide, etc., may be used with 5 to 7 mols. of alkali metal hydroxide used for the treatment of the ore, which may be such as to produce a liquid extract directly. Alternatively a solid mass comprising alkali metal stannate crystals, to be subsequently extracted, may be produced. Tin may be recovered from the crystallised stannate by electrolysis, or from the oxide precipitated from a solution of the stannate. Specification 324,685 is referred to.—640,352, *A. H. Stevens* (*Vulcan Detinning Co.*).

New Machine makes White Bread without Agene

AFTER four years of research and testing, a machine has been developed by the Morton Machine Co. Ltd. which uses a process patented by Joseph Rank Ltd. for producing white bread without employing any chemical bleachers or improvers such as agene. Untreated and unbleached flour is used.

With this method, known as the 'aeration process,' half the flour used in the final dough is whipped with water at very high speeds in this machine for approximately 5 min. During that period sufficient oxygen is taken from the atmosphere to produce a batter which, when discharged from the mixer, acts as an oxidising agent to bleach and improve the other half of the flour in a normal dough-kneading machine.

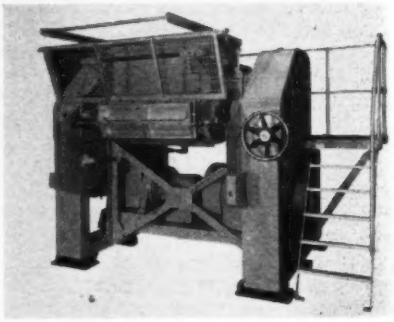
The Morton machine prepares the batter which requires violent agitation at very high speeds to make possible the process of utilising the oxygen of the atmosphere. This agitation is achieved by two statically-balanced blades (see p. 72), the completion of the process being determined by electrical reading.

For the past 18 months bread has been produced commercially on these machines by Beatties Bakeries of Glasgow—the largest bakers in Scotland—where a substantial proportion of their bread is made by the 'aeration process.' In their new factory at Dundee the whole of their bread production is made this way without any chemical improvers or bleachers.

The machine is driven by a 60-h.p. Brush electric motor operating through a gear box to a chain drive which in turn drives helical gears on both beaters. The container of the mixer is of special shape to facilitate discharge of the batter and is jacketted for temperature control, which is vital to the mix. All safety guards are electrically interlocked during operation.

The weight of the machine is 5½ tons, height 7 ft. 2 in. and overall length 10 ft. 10 in.

The one-sack (280 lb. of flour) machine



High-speed bread mixer, with discharge door open and safety grill raised.

is not designed for doughing, but is capable of feeding a number of the orthodox types of dough-kneaders. The 'aeration process' demands great accuracy in proportions of flour and water as well as a rapid and automatic handling of each charge. Special flour-handling and -weighing plant and an automatic tempering and measuring tank have been arranged so that it is possible for one operator to control the entire process from the same platform, with the exception of discharging the batter into the dough-mixing pans.

Small bakeries have been catered for with an extra heavy vertical mixer incorporating special features. In addition to beaters necessary for the 'aeration process,' standard equipment can be supplied. This machine will handle up to quarter-sack capacity and will also complete the doughing without removing the batter from the pan.

At a recent Press conference, two loaves were produced. One had been made by the new process, the other by the normal method. There appeared to be no difference in colour and texture between them. It was reported that no difficulties had been experienced with any kind of flour, whether ground from home-grown or imported wheat.

CHEMICAL SOCIETY
REFERENCE
LIBRARY

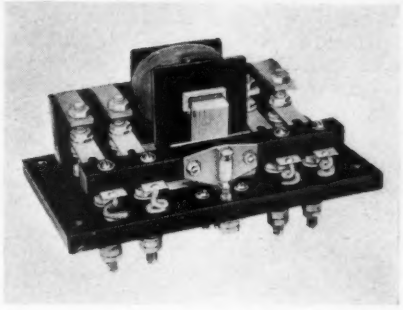
Plant and Equipment

Heavy-duty relay

A new heavy-duty relay, falling between the general-type commercial relay switching up to 5 amp. and the higher-rated contactor types, has been developed by Electro Methods Ltd. It has the advantage of requiring very low operating power.

Heavy-duty relays for either A.C. or D.C. operation are available in two forms: two-pole change-over and four-pole change-over. In view of their compact design, they are suitable for use in confined locations, such as control lines and switchboards, where conservation of space is an important factor. Their uses include the control of power loads, lighting loads and interlocking circuit switching systems.

They are operated by any two-wire control device, *e.g.* push-switch, toggle-switch, relay or thermostat. Alternatively, three-wire control can be arranged by utilising a free 'normally open' contact on the relay for holding on. Heavy-duty relays are assembled on a fully insulated base for back connection and can be supplied complete with dust cover.



Relay for control lines and switchboards.

Improved pH meter

A new *p*H meter and millivoltmeter has been produced by W. G. Pye & Co. Ltd. This is a modification of the standard model and incorporates both manual and automatic temperature compensation and a range of electrode parts which would enable different assemblies to be made up to deal with diverse measuring conditions. The meter is mounted on a sloping panel to give comfortable reading. The controls are grouped conveniently on the vertical panel, as are the input sockets. The mains connector and associated accessories are placed out of the way at the back. On opening the hinged lid at the top, an accessory box can be withdrawn; this contains the *p*H electrodes and associated equipment.

The instrument is operated in the following manner. It is switched on by means of the main selector switch and the accessory box is taken from its compartment. Buffer tablets of three specified *p*H values are provided in this box. One tablet of the value lying in the *p*H range being measured is dissolved in distilled water in the graduated bottle and the solution made up to the mark.

The selector switch is turned to the *p*H range required, either 0 to 8 *p*H or 6 to 14 *p*H. The 'check zero' button is depressed and the pointer brought to zero by the 'set zero' knob. A small quantity of buffer solution is placed in the beaker and the electrodes lowered into it. The 'set buffer' knob is then adjusted until the pointer reads the stated *p*H of the buffer solution.

The instrument is now ready for use and no other adjustments of any kind are normally required. No further reference need be made to the buffer solution, and the 'set buffer' knob is provided with a clamp so that it can be locked against accidental interference. The zero of the instrument can be checked in an instant by depressing the 'check zero' button; zero wander is not more than ± 0.02 *p*H and for most purposes is negligible. For extremely accurate work the necessary correction can be made by a slight shift of the 'set zero' knob.

The electrode kit supplied with the *p*H meter allows nearly every type of *p*H measurement to be carried out. The electrodes themselves consist of a small-bulb glass electrode, covering the full range 0 to 14 *p*H; and a calomel reference electrode with wick-type liquid junction. The reference electrode is fitted with a special sealing arrangement at the top to prevent creeping of potassium chloride solution. This arrangement allows for withdrawal of the interior element when refilling with potassium chloride solution is necessary.

The electrodes may be fitted up to form three different assemblies, the sheathed, open and micro, each of which may be mounted in two ways.

Portable liquid transfer unit

The *Langfilcon* is an easily-operated portable unit designed for transferring liquids from one container to another at any speed. It has been primarily constructed to operate in the production unit itself, *i.e.* mixing machine, process tank or storage vessel. It need not be permanently installed, and does not therefore require factory floor space. Wall-, bench- or floor-mounted models are, nevertheless, available.

pH meter and millivoltmeter.

It automatically incorporates any sediment, and will work equally well in large or small containers. The contents of one vessel can be transferred into another container, or into a batch of containers simultaneously if the multi-discharge head is used, quickly and cleanly, with a minimum of aeration.

The unit operates continually. Flow begins immediately on starting up, but is controlled by a simple cock on the outlet branch. If it is necessary temporarily to discontinue filling there is no need to stop it as the flow of liquor is independently controlled by the operator whilst the machine is in motion. Thus the flow can be increased, decreased or stopped entirely at will, but is nevertheless immediately available as soon as required.

The unit can be cleaned by working it for a minute or two in water or solvent.

The machine is available in a wide range of sizes for manual or power operation, all of which can if necessary be suitably constructed to suit the particular needs of individual customers. Lang-London-Ltd. are the makers.

Welding accessory

A new type, fully-insulated electrode holder for use in welding operations has been patented by a Norwegian firm, Laukvik Welding Products, Oslo. The firm claims that a new and simplified construction guarantees a firm hold on the electrode, pressing it tightly against the head of the holder through the use of a pivoted lock plunger. In this way, torsional strain between lock plunger and electrode is avoided. There is no danger of the electrode working loose upon impact with the work piece.

This type of construction, it is claimed, makes it possible to use a larger-diameter plunger, ensuring an exceptionally good contact between the electrode and the head of the holder. Danger of burning is eliminated, as the plunger is coated with a heat-resisting material.

Flexible metal tubing

A new tubing for a wide range of industrial applications has been produced in the U.S. Intended for such applications as air handling, fume removal and dust collection, the new tubing can be used in exhaust, blowing or gravity systems. It is made of a rust-resistant wire helix, covered with woven fabric coated with a tough resinous compound. It is light in weight and has a relatively smooth bore and negligible reduction of cross-sectional area in tight bends. It has good resistance to oils, gases, acids, alkalis and abrasion and resists flames. Makers are the Flexible Tubing Corpn.

World News

GREAT BRITAIN

Power-Gas to make German acid plants

The Power-Gas Corporation Ltd. has announced the conclusion of an arrangement with Chemiebau Dr. A. Zieren G.m.b.H., of Nieder-Marsberg, Germany, whereby they are able to manufacture and sell a complete range of sulphuric acid plant and associated equipment to Chemiebau designs.

The arrangement with Chemiebau covers processes for the production of sulphuric acid from hydrogen sulphide, sinter gases, sulphur, pyrites, spent oxide, gypsum and other sulphur-bearing materials in both vanadium contact and *Intensiv* tower-type plant.

The arrangement also covers the manufacture of auxiliary and related equipment comprising vacuum and high concentration plants, mechanical sulphate burners, rotary furnaces, reduction kilns and electrostatic filters for dust and mist precipitation.

The Power-Gas Corporation are accustomed to handling complete contracts for the gas and chemical industries and it is their intention to contract for complete installations including erection and initial operation.

Descfiptive literature on this subject is available for firms who are interested.

Wulff acetylene process

The Fluor Corporation Ltd. has entered into an agreement with the Wulff Process Co. under which Fluor is authorised to design and construct plant for application of the Wulff process. The process uses natural gas, ethane, propane, butane or any L.P.G. mixture as feed stock and produces low-cost acetylene. It may be applied to plants making as little as 1 ton/day of acetylene, or as much as 100 tons/day. The process can be operated to produce substantial yields of commercial-grade ethylene simultaneously. The Fluor Corporation is represented in the sterling area by Head Wrightson Processes Ltd., London, E.C.1.

Appointment by Thermocontrol

Mr. E. H. Walker, A.M.I.E.E., recently accepted the appointment as chief engineer to Thermocontrol Inst. Co. Ltd. In January 1948, Mr. Walker, who was senior control and installation engineer for the firm, left them to take up an appointment in Ceylon. Last summer, on six months' leave in England, he took a 'busman's holiday' and spent much of his time working in the firm's office. New contracts for automatic controls for high-pressure hot water, air-conditioning and combustion schemes, led Dr. Taylor and Mr. A. E. Cox, directors of the company, to persuade Mr. Walker to take up the new appointment with the firm which has now been announced.

Sulphur control relaxed

The Minister of Materials has made the Control of Sulphur Order, 1953 (S.I. 1953, No. 232), which revokes all statutory control on the supply and use of sulphur except for sulphuric acid manufacture and which came into effect on February 23.

'It is possible to do this because of an increase in world production of sulphur and because of economies in its use and its substitution by other materials in the manufacture of sulphuric acid,' states the Minister. His statement continues: 'Sulphur is still not available in unlimited quantities, but provided that economy in its use continues . . . sufficient should be obtainable to meet the essential needs of the U.K.

'Control of sulphur for making sulphuric acid is being retained because it is necessary that sulphur should be used only to the extent that requirements for acid cannot be met by using other materials. Apart from pyrites, these include anhydrite, of which there are large deposits in this country, and spent oxide, which is a by-product of gas works. There has been a considerable expansion of plant using these materials which is now coming into use . . . . There can be no assurance that there will not be another serious shortage of sulphur within a few years. For these reasons, imports of sulphur will continue to be restricted to the level necessary to meet essential requirements.'

NORWAY

More from Zn, Pb, and S deposits

Plans are being made to increase the production of the rich deposits of ores in Bleikvassli, at Korgen in Helgeland, which contain lead, zinc, sulphur and copper. A production rate of 50,000 tons p.a. is planned, compared with the present 10,000 to 12,000 tons. The necessary development of the mine will cost between 4 and 5 million kroner, and it is expected to attain an annual production of 2,000 tons of lead concentrate, 5,000 tons of zinc concentrate, about 15,000 tons of sulphur pyrites, and 200 tons of copper concentrate.

Iron ore fields exploration

The Norwegian Government proposes to spend £100,000 this year on further exploration of the Dunderland iron ore fields in north Norway. Borings made so far have proved the existence of about 200 million tons of ore, and there is probably considerably more. There will be further drillings this year, and it is also proposed to establish pilot plants for refining the ore. As the Dunderland ore contains only 33% iron, a considerable refining will be necessary to secure a concentrate for commercial marketing. Refining raises a number of problems which will be examined at the new refining laboratory now under construction at the technical college at Trondheim.

World aluminium output

World production of aluminium in 1952 was nearly equal to the peak production of 1943 which totalled 1,870,000 metric tons, according to a survey issued by the Norwegian Aluminium Co. Plans approved in 1951-52 for expanding output will in the course of the next three years increase annual production by almost another million tons. Although the major expansion plans are in the U.S. and Canada, Europe also plans to increase output by 150,000 tons, and Norway will contribute 50,000 tons to this increase.

The new aluminium plant at Sunndalsöra, west Norway, to produce 40,000 tons p.a., will be ready in 1954-55. Norway's production of aluminium last year was 51,700 tons. The demand for raw aluminium for export is still strong, says the Norwegian Aluminium Co.'s report, but for semi-manufactured aluminium products prices have dropped in the last six months owing to reduced orders from the armaments industry, particularly in Britain. The basic price of raw aluminium on the home market is lower in Norway than in any other country in Western Europe, £137 10s., compared with £163 10s. in Britain, £183 10s. in France and £204 10s. in Switzerland.

FINLAND

Chemical production and import figures

Total production of Finland's three sulphuric acid factories at Harjavalta, Lappeenranta and Kokkola, reached about 130,000 tons in 1952, against 116,000 tons in 1951 and 94,000 in 1950. Increased output resulted from the expansion of the Kokkola factory which produced 45,000 tons, or some 50% more than in the previous year.

A new ammonium sulphate plant went into production at Kokkola in September 1952 at an annual output rate of 15,000 tons.

A total of 190,000 tons of raw phosphate was imported during 1952. This was sufficient to cover the country's requirements. Other imports were: 84,000 tons of nitrogenous fertilisers (65,000 tons in 1951); 20,000 tons of superphosphate (40,000); about 33,000 tons of fine phosphate (same); 10,000 tons of bone meal (nil) and about 69,000 tons of potassic fertilisers (70,000). Supplies of potassic fertilisers were generally adequate.

SWEDEN

Sulphur supply raised

To increase Sweden's sulphur supply, the Riksdag authorised the Government in May 1952 to lease its Rudtjeback pyrites mine to Bolidens A.B. for a period of 20 years, beginning in January 1953.

The deposit, estimated to contain at least 3 million metric tons of pyrite ore,

was mined only intermittently until the world sulphur supply became critical.

Under an existing agreement, Bolidens will extract for the Government about 50,000 tons of crude pyrites (30,000 tons of pyrite concentrates) in 1952. Under the new lease, 100,000 tons of crude ore will be mined annually to be converted into approximately 64,000 tons of concentrate at the company's plant at Kristineberg, which is being enlarged.

This development will increase total production of pyrites to 470,000 tons in 1953, compared with a previous high of 424,000 tons in 1949.

Consumption of pyrites is at an annual rate of 500,000 tons, about 50% for the manufacture of sulphite pulp and the remainder for sulphuric acid.

Norway supplied 72,245 tons of the 74,260 imported in 1951.

HOLLAND

New synthetic fibre

A new synthetic fibre called *N*53 is now being produced by N.V. Kunstzijdespinnerij Nyma, of Nijmegen. The basic material for this fibre is polyacrylonitrile and it belongs to the same family as *Orlon* and *Acrilon*. The new fibre is claimed to be easily blended with other natural or synthetic fibres and to be specially suited for use in curtains, upholstery and other similar materials.

Chemical plant project

Plans for the construction of a chemical plant at Delfzijl, Groningen, are well advanced, it is reported. The Dutch Government will advance some 60 million guilders for the construction of a salt and soda plant, new harbour facilities, pipelines and an electricity plant. The new chemical complex will derive its supplies of common salt from a rich seam discovered during 1952 near Winschoten.

The Government is understood to be preparing a bill on State aid for submission to Parliament in August. Construction of the new plant is expected to begin towards the end of the year.

TURKEY

Oil refinery at Batman

Construction of an oil refinery at Batman, in Turkey, is to be started within three months. The plant, which will have an annual capacity of 330,000 tons, will be completed in two years' time. It will be built by the Turkish Mining Institute with the technical co-operation of the American firm, Messrs. Ralph M. Parsons, of New York. The U.S. firm will, after completion of the plant, supervise operations for one year against payment of $425,000.

Cost of construction of the plant, including the laying of a 42-km. pipeline to bring crude oil from Raman and Gazan, is estimated at $6.9 million. It is believed that once the plant is operating, Turkey will save about T£25 million in foreign currency annually.

JAPAN

TiO_2 plant to be built with U.S. aid

The Glidden Co., paint manufacturers, has announced an agreement under which it will provide technical assistance for the large-scale production of titanium dioxide in Japan. The agreement calls for the construction of a $6 million TiO_2 plant in Japan, to be the largest of its kind in the Orient, by the Ishihara Chemical Co., of Tokyo and Osaka. Under the agreement, Glidden has licensed the Japanese company to use Glidden's processes and methods.

Glidden will receive stock in the Ishihara concern, a substantial down payment in American dollars and royalty payments over a period of years for its assistance.

INDONESIA

Soda plant to be built

A caustic-soda plant to be erected at Waru is scheduled for completion in 1954. Water from three adjacent rivers will be utilised.

It was originally planned to construct the plant at Madura, the chief source of salt, but the shortage of water there caused the shift. Like salt, soda is a monopoly of the Central Government, which has earmarked 7 million rupiahs (11.40 rupiahs = U.S.$1) for the project.

YUGOSLAVIA

New coke ovens and steel plants

At the close of 1952 the first battery of 35 ovens at the Lukavac cokery was put into operation, using American coal, and heating of the second battery of 40 ovens began with gas generated in the first battery. A little later, open-hearth furnaces began production. They will increase Yugoslav steel production by 100,000 tons p.a.; 45,000 tons at Jesenica, 10,000 tons at Gustanj and 45,000 tons at Zenica.

The Zenica rolling mill was also completed, but will not be put into operation until completion of an ore-dressing mill and blast furnaces in the same enterprise. Finally, production of small tubes started at Sisak, with a capacity of 20,000 tons p.a.

The completion of key projects, although behind schedule, is beginning to justify expenditures over the past six years.

BRAZIL

U.S. loan for manganese development

A $67.5 million loan to Brazil for developing new deposits of manganese ore and an 8½-year Government purchase contract have been announced jointly by the U.S. Export-Import Bank and the Defense Materials Procurement Agency.

The agreement is with Industria e Comercio de Minerios, of Rio de Janeiro, a Brazilian corporation partially owned by the Bethlehem Steel Co., of U.S.A. The agreement specifies that a minimum of 70% of the 5.5 million tons of ore to be produced from the mine must be exported to the U.S., with large production scheduled to start in 1956. The U.S. Government will take a total of 400,000 tons in 1956 and 1957 for stockpiling and defence uses. If required for production, the ore would presumably be sold by the Government to private companies.

The D.M.P.A. has guaranteed the company a 'floor price' of 65 cents/long ton unit (22.4 lb. of recovered manganese), based on 45 to 47% ore (c.i.f. eastern seaboard ports) for any part of its production offered to the U.S. Government up to a maximum of 5.5 million tons. The announcement added that the production area in the Amapa Territory was estimated to contain upwards of 10 million tons of ore.

Petroleum refining expansion

Brazil's growing petroleum refining capacity may equal 43% of requirements by 1954, according to the Government Trade Bureau.

The Government's Cubatao refinery should be in operation by 1954 with a 45,000-barrel/day output. This will be supplemented by 5,000 barrels/day from the Mataripo plant, now being enlarged, and by the combined production of two concessionary plants in the Federal District and Sao Paulo, plus three smaller plants in Rio Grande do Sul and Sao Paulo. The total production should be around 86,000 barrels/day. Consumption, currently around 140,000 barrels/day, is expected to increase to about 195,000 barrels/day by 1954.

By such steps Brazil hopes to cut down her dollar exchange drain by increasing domestic refining capacity and reducing fuel imports. Sizeable dollar savings are already being effected by Brazil's tanker fleet, now totalling 222,000 tons.

MEXICO

Petroleum target raised

According to a report by the International Bank, production of petroleum and derivatives in Mexico must reach an annual level of 104 million barrels by 1956 if it is to be adequate for domestic demand. Petroleos Mexicanos, the national petroleum monopoly, plans to spend some 300 million pesos in 1953. Projects include the building of a sulphur plant at Tampico, the opening of three new refineries at Salina Cruz, Mazatlan and Guaymas and the expansion of daily refining capacity at Ciudad Madero (near Tampico) to 47,250 barrels and at Arbol Grande to 16,600 barrels.

Several more productive drillings have been made in the new Tenixtepec oilfield. During his visit to the Papaloapan valley, President Aleman announced the discovery of oil in that region. An oil pipeline measuring 132 km. has been built in 90 days from the Salamanca refinery to Lagos de Moreno, and a gas pipeline has been opened between Monterrey and Saltillo.

Loan for sulphur-extraction plant

The Export-Import Bank has authorised

a loan of $3.6 million to the Mexican Gulf Sulphur Co. (a subsidiary of the Pan American Sulphur Co.) for the building of a sulphur-extraction plant at Jaltipan. The loan will bear a 5% annual interest and will be amortised in 12 half-yearly payments from the date when the loan becomes effective. It is held that modernisation of Mexican methods of sulphur extraction is much needed if the Mexican product, which at present sells at about U.S.$100/ton, is to become competitive in the world market.

VENEZUELA

Phosphate reserves may be exploited

Geologists from a U.S. company have discovered extensive deposits of phosphate rock in Falcon, in the Riecito Mountains, according to a report from Caracas.

About 15 million metric tons of high-quality rock are estimated to be available for immediate exploration and 5 million more in reserve. The discovery, if confirmed, will make possible the production of phosphatic fertilisers, using sulphuric acid from a plant planned for construction at Maracay.

PAKISTAN

New sulphur refinery

Construction of a sulphur-refining plant will begin in Quetta in June. Permission to build the plant has been given by the authorities to the company, Nasir Trading House Ltd. It is scheduled to come into production towards the beginning of 1954.

Machinery and technicians are being sent from Western Germany. Initial output is put at 5 tons/day of refined sulphur.

Soda and fertiliser projects

The Pakistan Industrial Development Corporation is beginning construction of a 3,500-ton caustic-soda plant at Nowshera, Northwest Frontier Province, in collaboration with M. M. Ispahani Ltd.

The corporation also contemplates the building of an ammonium-sulphate factory in the Mianwali District and has completed plans for a superphosphate plant in conjunction with sulphuric-acid facilities at Lyallpur.

INDIA

Electrochemical research

The Electrochemical Research Institute at Karaikudi (Madras) was opened by Dr. Radhakrishnan, the vice-president, early this year. Among the functions of the Institute are the training of technological workers, and research in the fundamental and applied aspects of electrochemistry. Its location in Karaikudi was decided upon in 1948. Part of the cost of the Institute has been donated by Dr. Alagappa Chettiar. The buildings stand on a 300-acre estate.

Oil in Bengal

Dr. J. C. Ghosh, director of the Higher Technological Institute, Kharagpur, said in Lucknow that there were prospects of finding rich oil deposits in the Bengal basin and the Standard Oil Co. had planned to spend Rs. 100 million in the next five years on drilling oil.

He also disclosed that the Government plans for the manufacture of synthetic petrol in the country were in a very advanced stage.

Dr. Ghosh, who was speaking on the 'Petroleum Industry in India,' said India imported petroleum worth Rs. 370 million annually and, as a result of the two refineries that were being set up in Bombay, India was likely to make a saving of Rs. 200 million, since import of crude oil worth Rs. 100 million would be sufficient to meet the country's petroleum needs.

Dr. Ghosh said that the recent oil prospecting in the Bengal basin had been done through the latest method of a magneto-meter fitted to an aeroplane.

At present, India produced hardly 10% of the petrol required for her needs.

New cement plant at Sindri

The Associated Cement Co. of India have reached agreement with the Indian authorities for the construction of a 200,000-ton p.a. cement plant at Sindri. The chairman of the company said the new plant would use calcium carbonate sludge produced at the Sindri fertiliser factory.

He said the company's production—excluding its plants in Pakistan—was around 2 million tons annually. It was hoped to increase this figure to 3.13 million tons by 1960-61.

Plans for building a cement factory at Sindri were discussed in CHEMICAL & PROCESS ENGINEERING, July 1952, 385.

SOUTH AFRICA

New uranium plant

The Harmony Gold Mining Co., near Ventersburg, Orange Free State, has announced that it is to begin building plant for the production of uranium from residue slimes of gold production. The plant, to be built by arrangement with the Union's Atomic Energy Board, will be ready for production in the latter half of 1954, it is estimated.

The contract with the Atomic Energy Board will be for 10 years and, the company's board of directors said, arrangements are being made through the Atomic Energy Board for loans to meet the plant's capital cost.

New chrysotile deposits

An important new chrysotile field may soon be established by the Onverwacht Asbestos Mining Corporation in an area where the existence of such deposits was unknown until recently. Announcing this, the company chairman said that the company's rights on the area—some 60 miles north of Zeerust in the Transvaal—covered a wide expanse. Excellent quality chrysotile fibre was contained in a very large serpentine mass with an ample water supply and favourable transport facilities, the chairman added.

AUSTRALIA

Tin, wolfram and uranium prospecting

Two small mineral-producing areas at Maranboy and Yeuralba, near Katherine, might have sufficient deposits of tin ore to make Australia independent of imported supplies. According to Australia's National Development Minister, in a 1952 mineral survey, investigations had revealed that the Maranboy deposit, formerly worked by two-man parties, could be developed into a field by modern methods. A company is now operating on the deposit. At Yeuralba, 20 miles away, sampling and detailed surveys had shown the existence of large, low-grade ore bodies containing tin and wolfram. This field had been tested on the surface only and further detailed exploration was required.

At Mount Marumba, in the centre of Arnhem Land, the Zinc Corporation have found deposits of zinc ore containing up to 40% zinc. Surveys are continuing elsewhere.

The Minister said considerable detailed work on uranium was proceeding in the Northern Territory. In the same area there was evidence of copper. Also, an extensive mineralised field was being explored in the Mount Isa-Cloncurry area for new deposits of copper, gold, silver, lead and zinc. Discoveries made recently established a new concept of factors governing ore occurrence in this area and already had led to the finding of new lead-zinc prospects.

Bauxite deposit discovered

Ten million tons of bauxite have been found in one deposit on the Wessel Islands off the north coast of Arnhem Land. Two other deposits on the nearby mainland close to Cape Arnhem have not been tested for size, but, according to Australia's National Development Minister, they are thought to be bigger than the Wessel Island deposit. This could provide bauxite 'for a few hundred years' for Australia's first aluminium-producing plant now being built at Bell Bay, Tasmania (see CHEMICAL & PROCESS ENGINEERING, January 1953, 20). Easy access by sea would permit low-cost extraction and shipment to Tasmania.

More coal found in N.S. Wales

Coal reserves of more than 25 million tons have been located in the northern coalfields of New South Wales, and surveys have revealed at least another 25 million tons at greater depths. All of this is of commercially workable quality and some is fair-quality gas-making coal, which could make an important contribution to ending the shortage in the southern states.

Products from wool grease

Over 70,000 tons of wool grease is available in Australia's annual clip. This, according to an official announcement by the Commonwealth Scientific and Industrial Research Organisation, could yield products worth up to A£1,000 a ton if

treated chemically. Exploitation of wool grease might prove an important factor in favour of wool in the competition between wool and synthetic fibres. The Organisation's research has shown that under controlled conditions chemical breakdown could be accomplished easily and cheaply.

Waxes, when fully exploited, would represent a major by-products industry. Wool waxes are unique among other industrial waxes in having a high content of cholesterol, used in the production of vitamin D and the sex hormones. Other commercial applications of wool wax products are detergents, lubricants, corrosion preventives, paint driers, defrothing oils, marking inks, linoleum, plastics, polishes, paper size and adhesives.

Anglo-Iranian's new refinery

On the site of the Anglo-Iranian Oil Co.'s new A£40 million refinery at Kwinana, near Fremantle, Western Australia, work is being pushed ahead on the grading and levelling of the site, while building of a construction camp is about to start. The first shiploads of material, mainly steel plate for tankage, reinforcing steel, jetty equipment and construction machinery, are now on the way from the U.K. and America to Kwinana.

CANADA

U.S.-Canada oil pipeline to be extended

The Interprovincial Pipe Line Co. Ltd., of Canada, through its U.S. subsidiary, the Lakehead Pipe Line Co., plans to extend the line which now runs from Edmonton, Alberta, to Superior, Wisconsin, across northern Wisconsin and Michigan to Sarnia, Ontario, and thus to eliminate the need for transporting crude oil by tanker to that point.

Although financing arrangements are not yet completed, no difficulties are anticipated in obtaining the necessary backing. The cost of the extension is estimated at $90 million, about the same as that of the Edmonton-Superior line. Construction is planned to begin early in 1953 and to be completed before the end of the year.

The U.S. Petroleum Administration for Defence is reported to have allocated for the first quarter of the year 45,000 tons of the approximately 160,000 tons of pipe required to complete the line.

The new 30-in. line will have an initial throughput of about 83,500 barrels/day, the president of the company states. The pipe will be of sufficient size to permit an increase in capacity to 300,000 barrels/day by the installation of additional pumping stations if the need for greater capacity arises.

When the extension is completed the capacity of the present Edmonton-Superior line will have been increased from 95,000 barrels/day to about 125,000. Furthermore, the line will be operated at close to capacity in all seasons, as it will no longer be necessary to store crude at Superior.

The present annual average throughput is appreciably less than capacity, because of the necessity of reducing daily throughput far below capacity during the winter.

Completion of the extension to Sarnia will represent another long step in Canada's progress toward petroleum self-sufficiency. When this line and the Trans-Mountain pipeline are completed in 1953, Quebec and the Maritime Provinces will be the only parts of Canada still dependent on imports of crude oil.

UNITED STATES

Acid and sulphur targets

The Defence Production Administration has called for additional capacity to produce 17.5 million short tons of 'virgin' sulphuric acid annually by January 1, 1955, as its final chemical expansion goal. This would be 4.1 million tons over capacity on January 1, 1951. Separate expansion of capacity for the recovery and treatment of spent sulphuric acid is also provided for in the expansion goal.

At the same time, the expansion goal for crude sulphur was reduced from 8.4 million long tons by 1955 to 7.7 million by 1956. Enough applications for fast tax-write-off certificates had been received by the agency to cover the sulphuric acid goal, but it said further applications will be needed even to achieve the lowered sulphur goal.

An official explained that no expansion goal for sulphuric acid could be established until goals for all other chemicals had been set, since sulphuric acid is used in the manufacture of a great many chemicals.

In connection with the announcement of the sulphuric acid expansion goal, the National Production Authority issued a report summarising the position of the 57 chemical expansion goals so far set.

Sufficient facilities have been assured through Government-assisted and unassisted expansion to meet 41 of the 57 expansion goals, the N.P.A. reported. These expansion goals have been set on the basis of partial mobilisation. For some time requirements under all-out mobilisation have been going on and this may result in the revising upward of expansion goals for key chemicals.

The Leonard Hill Technical Group

Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—The Physical Control of Odours; The Sympathomimetic Amines; Modern Veterinary Medicaments, Part 2; Progress Reports on Antibiotics, Perfumery.

Food Manufacture—Vitamin Progress in 1952; The Baking Industry; Shell Fish for Human Consumption.

Fibres—A review of processes to assist the end uses of textile fibres; New machinery and processes for fibres production and usage.

World Crops—World Timber and Pulp Requirements; The Agricultural Possibilities of Morocco; Changes in the Fertiliser Industry of the United States.

Building Digest—The Painting of Buildings; Painting and the Architect: the new approach.

Muck Shifter—The Construction of the Danube-Black Sea Canal; Transport and Civil Engineering Contractors; A High-speed Pipeline Operation at Harburg Refinery.

Book Reviews

Absorption and extraction

Because of greatly increased interest in the subject of mass transfer between phases, since the book was first published in 1937, this new edition* is much longer than its predecessor. Some of the fresh material concerns the new theory of mass transfer from a surface to a turbulent fluid stream, and the relationships between fluid friction, heat transfer and mass transfer.

Two completely new chapters have been added. Chapter 2 describes the elementary concepts of fluid friction and turbulence, as a basis for the understanding of eddy diffusion and the analogies between heat, mass and momentum transfer. Chapter 3 summarises the data on mass transfer to simple solid shapes and is based largely on experiments in which liquids were allowed to evaporate into gas streams.

The contents of the earlier edition have been carefully revised, so that little of the original material has been retained in the same form.

Solubility and equilibrium data on gas-liquid and liquid-liquid systems have been omitted, because inclusion of the necessary tables would duplicate summaries published by other authors.

Modern chemical plants

This is a collection of articles on chemical plants which originally appeared in *Industrial and Engineering Chemistry* in the series of 'Staff-industry collaborative reports.'† All follow a definite pattern designed to give the background of the process, descriptions of the installation and its operation, the economics of the process, personnel and future prospects. Bearing in mind that each article describes an actual commercial plant, the wealth of detail given is remarkable and will excite the envy of anyone who has tried to obtain similar information from British firms. In every case the words are accompanied by photographs and flowsheets. The range of subjects is remarkably wide, including TNT and brewing, kraft paper and bacitracin. In all there are 24 articles.

**Absorption and Extraction*, by T. K. Sherwood and R. L. Pigford. Second edition. McGraw-Hill. Pp. 478 including index. 64s. net.

†*Modern Chemical Processes*. Vol. 2. Chapman & Hall, 1952. Pp. 299. Illus. 40s. net

MEETINGS

Institution of Chemical Engineers

March 14. ' Pneumatic conveying: Part 1—The pressure drop during horizontal conveyance,' by D. M. Newitt, J. F. Richardson, R. H. Clark and D. E. Charles, 3 p.m., The University, Edmunds Street, Birmingham.

Chemical Society

March 13. ' Changes occuring in the surface of solids during chemical reactions,' by Prof. W. E. Garner, 4.30 p.m., Chemistry Lecture Theatre, The University, Edgbaston, Birmingham.

March 13. ' Crystal and molecular structure—X-ray and electron-microscope studies,' by Prof. J. M. Robertson, 7.45 p.m., Chemistry Department, Trinity College, Dublin. Joint meeting with the Werner Society.

March 13. ' Catalytic inorganic halides and the Friedel-Crafts reaction,' by Dr. F. Fairbrother, 5.30 p.m., Chemistry Building, King's College, Newcastle-upon-Tyne.

March 13. ' The mechanism of detergent action,' by Prof. N. K. Adams, 5 p.m., New Chemistry Building, The University, Southampton. Joint meeting with R.I.C.

March 13. 'Acids containing fluorine,' by Prof. M. Stacey, 5.30 p.m., Chemistry Department, University College, Swansea. Joint meeting with the R.I.C.

March 16. ' Some recent developments in theoretical organic chemistry,' by Prof. M. J. S. Dewar, 5.30 p.m., Chemistry Department, University College, Cardiff.

March 19. ' Some new applications of infra-red spectroscopy,' by Dr. H. W. Thompson, 7. p.m., Chemistry Department, The University, Bristol. Joint meeting with the R.I.C. and S.C.I.

March 19. ' Radiation chemistry,' by Prof. F. S. Dainton, 7.30 p.m., North British Station Hotel, Edinburgh. Joint meeting with the R.I.C. and the S.C.I.

March 20. ' The production and refining of shale oil,' by Dr. G. H. Smith, 7 p.m., Chemistry Department, University College, Dundee. R.I.C. lecture.

March 26. ' Some recent developments in the field of lipids,' by Dr. J. A. Lovern, 7.30 p.m., Robert Gordon's Technical College, Aberdeen. Joint meeting with the R.I.C. and the S.C.I.

March 27. One-day symposium, ' Corrosion inhibitors,' College of Technology, Manchester. Joint meeting with the R.I.C. and the S.C.I.

Society of Chemical Industry

Chemical Engineering Group

March 17. ' Objectivity in the design of sulphuric acid plants,' by Stanley Robson, 5.30 p.m., Burlington House, Piccadilly, London, W.1.

Plastics and Polymer Group

April 7. ' Recent advances in the ionic reactions of rubber,' by Dr. M. Gordon and J. S. Taylor, 6.30 p.m., Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1.

Road and Building Materials Group

March 19. ' Differential thermal analysis and its application to the study of building materials,' by D. B. Honeyborne, 6 p.m., The Building Centre, Store Street, Tottenham Court Road, London, W.C.1.

Royal Institute of Chemistry

March 12. ' Smoke,' by Dr. A. C. Monkhouse, 6.30 p.m., Yarborough Hotel, Grimsby. Joint meeting with Scunthorpe Chemical Engineering Group.

March 17. ' The importance of analytical chemistry in industry with some observations on the training of analytical chemists,' by J. Haslam, 8 p.m., The Cherry Tree, Welwyn Garden City, Herts.

Incorporated Plant Engineers

March 18. ' Fluid flow,' by R. F. Walters, 7 p.m., Bull Hotel, Rochester, Kent.

March 18. Annual General Meeting followed by ' Some aspects of metallurgy in plant engineering,' by J. Hinde, 7.15 p.m., Grand Hotel, Bristol.

Institute of Fuel

March 17. ' Progress in underground gasification,' by C. A. Masterman, 6 p.m., James Watt Institute, Great Charles Street, Birmingham 3.

March 20. ' The heat pump,' by P. E. Montagnon, 7.15 p.m., Loughborough College. Joint meeting with Loughborough Scientific Society, Incorporated Plant Engineers and the Institution of Heating and Ventilating Engineers.

April 3. Annual General Meeting followed by film entitled ' Combustion ' (International Combustion Ltd.), 7 p.m., Royal Technical College, Glasgow.

Institution of the Rubber Industry

March 9. ' Some engineering aspects of belt conveying,' by J. J. Hickey, 7.15 p.m., Bull & Royal Hotel, Church Street, Preston.

March 13. 'A survey of developments in synthetic rubber-like polymers,' by Dr. Stocklin (Farbenfabriken Bayer), 7.30 p.m., Bell Hotel, Leicester.

March 16. ' Engineering for a new product,' by D. C. Crabbe, 7 p.m., Lecture Theatre, Electricity Showrooms, Whitechapel, Liverpool.

March 17. ' New developments in sponge and cellular products,' by W. R. Pryer and Dr. J. T. Watts, 7.30 p.m., 25 Charlotte Square, Edinburgh.

Institute of Metal Finishing

March 16. ' Detergents—with special reference to metal finishing,' by F. H. Bell, 6 p.m., Northampton Polytechnic, St. John Street, London, E.C.1.

March 27. ' Preparation and deposition of silver upon ferrous and non-ferrous metals,' by A. R. Knowlson, 7.30 p.m., Grand Hotel (Fitzwillian Room), Sheffield.

Manchester Association of Engineers

March 27. Annual General Meeting followed by ' Friction between solid bodies,' by Dr. R. Schnurmann, 6.45 p.m., Engineers' Club, Albert Square, Manchester 2.

Oil and Colour Chemists' Association

March 30. ' Styrene-butadiene latices and their application in water paints,' by J. F. Clark, 7 p.m., Royal Station Hotel, Kingston-upon-Hull.

CONFERENCES

March 15-20. American Chemical Society, 123rd National Meeting, Los Angeles, U.S.A.

Infra-red heating. An illustrated leaflet from the Stabilag Co. Ltd. gives details of use of their infra-red jackets for heating process plant. These jackets are claimed to be comparatively cheap to buy and install, to have a wide temperature range and to give temperature control to fine limits. The leaflet shows jackets fitted to valves, pumps, stills and pipes.

CHEMICAL & PROCESS ENGINEERING

ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following:

_____

_____

_____

_____

_____

For office use only. No. Date